Naval Facilities Engineering Command Southwest
BRAC PMO West
San Diego, CA

DRAFT
PARCEL E REMOVAL SITE EVALUATION WORK PLAN

RADIOLOGICAL CONFIRMATION SAMPLING AND SURVEY AT PARCEL E FORMER HUNTERS POINT NAVAL SHIPYARD SAN FRANCISCO, CA

October 2021

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October 2021

Prepared for:

Department of the Navy
Naval Facilities Engineering Command Southwest
1220 Pacific Highway
San Diego, CA 92132

Prepared by: EIP, Burlingame, CA
Contract Number: N62473-17-D-0011; Task Order No. N6247319F5198

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INTERNAL DRAFT
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Signature **Quality Control Manager**	**Date**
Signature **Radiation Safety Officer**	**Date**
Signature **Project Manager**	**Date**

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ACRONYMS AND ABBREVIATIONS

%	percent
^{60}Co	cobalt-60
^{90}Sr	strontium-90
^{137}Cs	cesium-137
^{214}Bi	bismuth-214
^{220}Rn	radon-220
^{222}Rn	radon-222
^{226}Ra	radium-226
^{230}Th	thorium-230
^{232}Th	thorium-232
^{234}U	uranium-234
^{235}U	uranium-235
^{238}U	uranium-238
^{239}Pu	plutonium-239
μCi/mL	microcuries per milliliter
AHA	activity hazard analysis
ALARA	as low as reasonably achievable
ANSI	American National Standards Institute
APP	Accident Prevention Plan
APTIM	Aptim Federal Services, LLC
ASTM	ASTM International (formerly American Society for Testing and Materials)
bgs	below ground surface
BMP	best management practice
BRAC	Base Realignment and Closure
BTV	background threshold value
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CDPH	California Department of Public Health
CFR	Code of Federal Regulations
CH2M	CH2M HILL, Inc.
cm	centimeter(s)
cm^2	square centimeter(s)
cm/s	centimeters per second
cpm	counts per minute
cpm/μR/hr	counts per minute per microroentgens per hour
CSM	conceptual site model
DAC	derived air concentration
dBA	decibels
DMP	Dust Management and Air Monitoring Plan
dpm	disintegration(s) per minute
dpm/100 cm^2	disintegration(s) per minute per 100 square centimeters
DOT	United States Department of Transportation
DTSC	Department of Toxic Substances Control
DQA	data quality assessment
DQO	data quality objective
EIP	Environmental Chemical Corporation-Insight Environmental, Engineering and Construction Inc.-Philotechnics, LLC
ERG	Environmental Restoration Group

ACRONYMS AND ABBREVIATIONS (continued)

ESU	excavation soil unit
FSS	final status survey
GPS	global positioning system
HAZWOPER	Hazardous Waste Operations and Emergency Response
HPNS	Hunters Point Naval Shipyard
HRA	Historical Radiological Assessment
ID	identification
IL	investigation level
keV	kiloelectron volt
LBGR	lower boundary of the gray region
LLRW	low-level radioactive waste
LWTS	liquid waste transfer system
m^2	square meter(s)
m/s	meters per second
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	minimum detectable concentration
MDCR	minimum detectable count rate
MLE	maximum likelihood estimate
MOU	memorandum of understanding
NA	not applicable
NaI	sodium iodide
NaI(Tl)	sodium iodide activated with thallium
NAVFAC	Naval Facilities Engineering Command
NAVSEA	Naval Sea Systems Command
Navy	United States Department of the Navy
NORM	naturally occurring radioactive material
NRC	Nuclear Regulatory Commission
NRDL	Navy Radiological Defense Laboratory
NUREG	Nuclear Regulatory Commission Regulation
OSHA	Occupational Safety and Health Administration
pCi/g	picocurie(s) per gram
Perma-Fix	Perma-Fix Environmental Services
PPE	personal protective equipment
PRSO	Project Radiation Safety Officer
Q-Q	quantile-quantile
QA	quality assurance
QC	quality control
RACR	remedial action completion report
rad	radiation absorbed dose
RAO	remedial action objective
RASO	Radiological Affairs Support Office
RBA	reference background area
RCA	radiologically controlled area
RCRA	Resource Conservation and Recovery Act
rem	roentgen(s) equivalent man
RG	remediation goal

ACRONYMS AND ABBREVIATIONS (continued)

ROI	region of interest
ROICC	Resident Officer in Charge of Construction
ROC	radionuclide of concern
ROD	record of decision
RPM	Remedial Project Manager
RPT	Radiological Control Technician
RSER	Removal Site Evaluation Report
RSEWP	Removal Site Evaluation Work Plan
RSO	Radiation Safety Officer
RSY	Radiological Screening Yard
RWP	Radiation Work Permit
SAP	sampling and analysis plan
SFU	sidewall and floor unit
SIMS	Survey Information Management System
SOP	standard operating procedure
SSHO	Site Safety and Health Officer
SSHP	Site Safety and Health Plan
SU	survey unit
SWP	stormwater plan
TCP	Traffic Control Plan
TCRA	time-critical removal action
TtEC	Tetra Tech EC, Inc.
TU	trench unit
UBGR	upper boundary of the gray region
USEPA	United States Environmental Protection Agency
VD	virtual detector
VOC	volatile organic compound
VSP	Visual Sample Plan
yd^3	cubic yard(s)

1.0 INTRODUCTION

This Removal Site Evaluation Work Plan (RSEWP) has been prepared by Environmental Chemical Corporation - Insight Environmental, Engineering and Construction Inc. - Philotechnics, LLC (EIP) to implement radiological soil sampling and survey investigation activities within Parcel E, Former Hunters Point Naval Shipyard (HPNS), San Francisco, California. The Parcel E investigation is being conducted for the United States Department of the Navy (Navy), Naval Facilities Engineering Command (NAVFAC) Southwest, under Contract No. N62473-17-D-0011, Contract Task Order N6247319F5198. The work elements under this Contract Task Order will be managed by Base Realignment and Closure Program Management Office West in San Francisco, California.

This RSEWP is based on the information provided in the *Final Parcel G Removal Site Evaluation Work Plan, Former Hunters Point Naval Shipyard, San Francisco, California* (Navy, 2019b) and includes EIP-specific personnel, site-specific work methodologies for work execution, radiological instrument information, and supporting documents. This RSEWP presents the tasks and procedures that will be implemented to investigate and evaluate radiologically impacted sites in Parcel E at HPNS. The location of HPNS is shown on **Figure 1-1**.

Radiological surveys and remediation were previously conducted at HPNS as part of a Basewide Time-Critical Removal Action (TCRA). Tetra Tech EC, Inc. (TtEC), under contracts with the Navy, conducted a large portion of the basewide TCRA, including sites within Parcel E. An independent third-party evaluation of TtEC data identified evidence of manipulation, falsification, and data quality issues with the data collected at Parcel E during the TCRA (Navy, 2017, 2019a). As a result, the Navy will conduct investigations at radiologically impacted soil and building sites in Parcel E that were previously surveyed by TtEC (**Figure 1-2**).

The purpose of the investigation presented in this RSEWP is to determine whether site conditions are compliant with the remedial action objective (RAO) documented in the Parcel E Record of Decision (ROD) (Navy, 2013). The RAO for radiologically impacted soil and structures is to prevent receptor exposure to radionuclides of concern (ROCs) at concentrations that exceed remediation goals (RGs) for all potentially complete exposure pathways. Additional reference background areas (RBAs) will be identified to confirm, or update as necessary, estimates of naturally occurring and man-made background levels for ROCs not attributed to Naval operations at HPNS. A statistical comparison of site data to applicable RBA data will be conducted.

The lead agency at HPNS is the Navy, and the lead federal regulatory agency is the United States Environmental Protection Agency (USEPA). The Navy will continue to work with USEPA and the State of California throughout the planning and site investigation process.

The approach for collecting and evaluating data is based on the following documents:

- Parcel E ROD (Navy, 2013);
- Basewide Radiological Management Plan (TtEC, 2012);
- *Final Parcel G Removal Site Evaluation Work Plan, Former Hunters Point Naval Shipyard, San Francisco, California* (Navy, 2019b); and

- *Draft Final Revision 1 Parcel G Removal Site Evaluation Work Plan Addendum, Radiological Investigation, Survey, and Reporting, Parcel G, Former Hunters Point Naval Shipyard, San Francisco, California* (Aptim Federal Services, LLC, 2020).

Based on a proposal by the regulatory agencies, a phased approach was designed to achieve a high level of confidence that the ROD RGs for soil (**Table 3-5**) are met. During Phase 1, 100 percent (%) of the soil associated with former sanitary sewers and storm drains at twenty (20) trench units (TUs) in Parcel E will be re-excavated and characterized. Soil sampling and scanning at the remaining thirty-seven (37) TUs will be performed during Phase 2 to increase confidence that current site conditions comply with the Parcel E ROD RAO. The survey design and implementation methods in this RSEWP are based on the regulator's proposal and comments, the Basewide Radiological Management Plan (TtEC, 2012), and compliance with the RGs in the Parcel E ROD. Therefore, only applicable elements of the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (USEPA et al., 2000) are incorporated.

The activities presented in this RSEWP will be conducted in accordance with the Sampling and Analysis Plan (SAP), which is included as **Appendix A**; the Accident Prevention Plan/Site Safety and Health Plan (APP/SSHP), which is provided under separate cover; and other plans, provided as Appendices. Specific procedures to ensure data quality and worker safety are described in the SAP and the APP/SSHP. Radiological project requirements, including personnel roles and responsibilities, required training, and health and safety protocols are presented in Section 6.0 of this RSEWP and in a Radiation Protection Plan (RPP), which is included as **Appendix C**.

A Contractor Quality Control Plan was prepared in accordance with *Unified Facilities Guide Specifications, Section 01 35 26, Governmental Safety Requirements* (Naval Facilities Engineering Command, 2015) and is included as **Appendix B** to this RSEWP. A Traffic Control Plan was prepared and is included as **Appendix D**. Environmental protection procedures are provided in the Stormwater Plan (SWP) and Dust Management and Air Monitoring Plan (DMP), which are included as **Appendix E** and **Appendix F**, respectively.

1.1 Scope of Work

The scope to perform the radiological survey and investigation consists of the following elements:

- Prepare planning documents and submit to the Navy and Regulators for approval.
- Provide management and oversight of all field activities including mobilization and demobilization, construction of temporary facilities, radiological controls and support, air monitoring, traffic control, and site maintenance.
- Phase 1 Evaluation – Excavate 20 TUs consisting of approximately 9,400 linear feet and 18,000 cubic yards (yd^3) followed by excavated soil characterization and management through screening on Radiological Screening Yard (RSY) Pads. Following screening of soil through RSY pads and authorization from Navy BRAC and RASO to backfill, return screened soil to the corresponding excavated trench unit.
- Phase 2 Evaluation – Investigate the remaining 37 TUs and the fill soil used for back fill by collecting soil samples with a drilling or direct-push rig and analyzing the soil.
- Former Building Sites – Conduct Final Status Surveys, including scanning and systematic

soil samples on all of the former soil survey units (SUs), consistent with the previous designs.

- Building Surveys – Conduct building surveys of the existing buildings on Parcel E, including scanning and systematic statics on the impacted portions of buildings.
- Manage and haul, if necessary, all generated wastes.
- Submit all data and a Remedial Action Completion Report (RACR).

1.2 Project Schedule

Figure 1-3 provides the project schedule for the Parcel E soil investigation and building survey activities.

1.3 Project Organization

Table 1-1 provides information on the key personnel associated with the project.

1.4 Site Safety

Field activities will be conducted in accordance with the project *Accident Prevention Plan / Site Safety and Health Plan, Parcel E, Former Hunters Point Naval Shipyard, San Francisco, California* (APP/SSHP) prepared by EIP (EIP, 2021). Applicable federal and California Occupational Safety and Health Administration regulations and permit requirements will be followed, as well as the *Safety and Health Requirements Manual, EM 385-1-1* (United States Army Corps of Engineers, 2014) and *Unified Facilities Guide Specifications, Section 01 35 26, Governmental Safety Requirements* (NAVFAC, 2015).

2.0 CONCEPTUAL SITE MODEL

This section provides an updated conceptual site model (CSM), which is presented in **Table 2-1**. The CSM summarizes the site description, history, and current status related to radiologically impacted buildings and former building areas, and former sanitary sewers and storm drains identified in the Historical Radiological Assessment (HRA) (Naval Sea Systems Command [NAVSEA], 2004). The sanitary sewers and storm drains were once a combined system identified as radiologically impacted because of the possibility that radioactive waste materials had been disposed of in sinks and drains, and the potential for the surrounding soil to be impacted by leakage and soil mixing during repairs. A removal action was initiated in 2006 at HPNS to remove the sanitary sewers and storm drains. The removal action included excavation of overburden soil, removal of pipelines, plugging of open sanitary sewers and storm drains left in place during the removal process, *ex-situ* radiological screening and sampling of the pipeline, and conducting final status surveys (FSSs) of the excavated soil and exposed excavation trench surfaces. Soil in Parcel E was removed to a minimum of 1 foot below and 1 foot to the sides of the sanitary sewer and storm drain piping.

Following the investigation and removal actions, allegations were made that the removal action contractor manipulated and falsely represented data. Some allegations have been confirmed. In addition, the on-site laboratory used a screening method to analyze radium-226 (^{226}Ra) that may have reported at levels higher than actual radioactivity. The removal action contractor presented CSMs in removal action completion reports that were based on potentially falsified data and screening results for ^{226}Ra reported by the on-site laboratory that were biased high.

The results of additional investigation activities presented in this RSEWP will be used to update the CSM, as needed.

3.0 SOIL INVESTIGATION DESIGN AND IMPLEMENTATION

This section describes the data quality objectives (DQOs), ROCs, RGs, investigation levels (ILs), and radiological investigation design and implementation for Parcel E soil.

3.1 Data Quality Objectives

The DQOs for the soil investigation are as follows:

- **Step 1 - State the Problem:** Data manipulation and falsification were committed by a contractor during past sanitary sewer and storm drain removal actions and current and former building investigations for soil. The Technical Team evaluated soil data and found evidence of potential manipulation and falsification. The findings call into question the reliability of soil data and issues regarding whether radiological contamination was present or remains in place are uncertain. Therefore, the property cannot be transferred as planned. Based on the uncertainty and the description of radiological activities in the HRA, residual radioactivity may potentially be present in soil.

- **Step 2 - Identify the Objective:** The primary objective is to determine whether site conditions are compliant with the Parcel E ROD RAO (Navy, 2013).

- **Step 3 - Identify Inputs to the Objective:** The inputs include surface soil and subsurface soil analytical data for the applicable ROCs and gamma scan survey measurements to identify biased soil sample locations. RBA surface and subsurface soil analytical data for ROCs will also be used to confirm, or update as necessary, estimates of naturally occurring and man-made background levels for ROCs not attributed to Naval operations at HPNS. The *Final Background Soil Study Report, Base Realignment and Closure, Program Management Office West, Former Hunters Point Naval Shipyard, San Francisco, California* (CH2M Hill, Inc. [CH2M], 2020) will be used to determine the appropriate RBA for the Parcel E investigation.

- **Step 4 - Define the Study Boundaries**: Phase 1 TUs, Phase 2 TUs, and Former Building Site Soil SUs are listed in **Table 3-1**, **Table 3-2**, and **Table 3-3**, respectively. Phase 1 TU locations are shown on **Figure 3-2**, Phase 2 TU locations are shown on **Figure 3-3**, and Former Building Site locations are shown on **Figure 3-6**.

- **Step 5 - Develop Decision Rules:**
  - If the investigation results demonstrate that there are no exceedances determined from a point-by-point comparison with the statistically based RGs at agreed upon statistical confidence levels, or that residual ROC concentrations are NORM or anthropogenic background, then a RACR will be developed. The RACR will describe the investigation activities, present the results of the investigation, compare the distribution of data from the sites with applicable reference area data, and provide a demonstration that site conditions are compliant with the Parcel E ROD RAO through the use of multiple lines of evidence including application of statistical testing with agreed upon statistical confidence levels on the background data.
  - If the investigation results demonstrate that Parcel E conditions are not compliant with

their respective RAOs, then a Removal Site Evaluation Report (RSER) will be developed in place of the RACR. The RSER will include recommendations for further action based on EPA's most recent guidance *Radiation Risk Assessment at CERCLA Sites: Q&A* (USEPA, 2014).

- **Step 6 - Specify the Performance Criteria:** The data evaluation process for demonstrating compliance with the Parcel E ROD RAO is presented in Section 5, depicted on **Figure 3-1**, and summarized as follows:
  - Compare each ROC concentration for every sample to the corresponding RG presented in Section 3.3. If all concentrations for all ROCs for all samples are less than or equal to the RGs, then compliance with the Parcel E ROD RAO is achieved.
  - Compare sample data to appropriate RBA data from HPNS as described in Section 6. Multiple lines of evidence will be evaluated to determine whether site conditions are consistent with NORM or anthropogenic background. The data evaluation may include, but is not limited to, population-to-population comparisons, use of a maximum likelihood estimate (MLE) or background threshold value (BTV), graphical comparisons, and comparison with regional background levels.
    - If all residual ROC concentrations are consistent with NORM or anthropogenic background, then site conditions comply with the Parcel E ROD RAO.
    - If any ^{226}Ra gamma spectroscopy concentration exceeds the ^{226}Ra RG and the range of expected NORM concentrations, then the soil sample will be analyzed using alpha spectroscopy for uranium isotopes (^{238}U, ^{235}U, and ^{234}U), thorium isotopes (^{232}Th, ^{230}Th, and ^{228}Th), and ^{226}Ra to evaluate equilibrium conditions. If the concentrations of radionuclides in the uranium natural decay series are consistent with the assumption of secular equilibrium, then the ^{226}Ra concentration is NORM, and site conditions comply with the Parcel E ROD RAO.
  - If any result is greater than the RG and cannot be attributed to NORM or anthropogenic background, then the Navy will be notified.

- **Step 7 - Develop the Plan for Obtaining Data:**
  - Phase 1 TUs – The radiological investigation will be conducted on 20 TUs (from 1 to 10 feet deep) associated with former sanitary sewers and storm drains in Parcel E (see **Figure 3-2**). For Phase 1 TUs, areas containing asphalt, asphalt base course, concrete, gravel, debris, or obstacles, if any, will be removed to expose the target soils. Soil will be excavated to the original TU boundaries, as practicable. Following excavation to the original TU boundaries, additional excavation of approximately 6 inches of the trench sidewalls and floors will be performed to provide *ex-situ* scanning and sampling of the trench sidewalls and floors. Excavated soil will be 100 % gamma scanned using the RSY pad process described in Section 3.6.3.1. Systematic and biased samples will be collected from the excavated soil for off-site analysis.
  - Phase 2 TUs – Additional investigation will be conducted on the remaining 37 TUs (from 1 to 10 feet deep) associated with former sanitary sewers and storm drains in Parcel E (see **Figure 3-3**) and the fill soil used for backfill. Each Phase 2 TU will be

investigated along with the fill soil used for backfill. The investigation includes soil sample collection via borings within the former trench boundaries and from soil representing the former trench walls and floors, as practicable. The borings will be advanced with a drilling or direct-push rig to approximately 6 inches below the depth of the previous excavation and will be gamma scanned upon retrieval. Fourteen (14) sampling locations will be placed within the fill soil and systematic cores will be placed every 50 linear feet along each trench sidewall. At least three samples will be collected from each boring. Soil samples will be collected continuously and described according to the Unified Soil Classification System. A gamma radiation scan will be conducted for each core.

- Former Building Site Soil SUs – The radiological investigation will be conducted at 122 SUs associated with surface soil at former building sites/areas in Parcel E (see **Figure 3-6**). The SUs will be investigated by conducting a 100 % gamma scan of the surface soil and collecting samples from systematic and biased locations for off-site analysis.
- The soil samples collected will be analyzed for the applicable ROCs by an accredited off-site laboratory, and the results will be evaluated as described in **Step 6**.

3.2 Radionuclides of Concern

The ROCs for Parcel E soil are based on the HRA (NAVSEA, 2004) and the Parcel E ROD (Navy, 2013) as presented in **Table 3-4**.

3.3 Remediation Goals

The soil data from the radiological investigation will be evaluated to determine whether site conditions are compliant with the RAO in the Parcel E ROD (Navy, 2013). The RAO is to prevent exposure to ROCs in concentrations that exceed RGs for all potentially complete exposure pathways. The RG for each ROC is presented in **Table 3-5**. The soil data will be compared to the applicable RGs using a single sample comparison and evaluated as described in Section 6.

If the investigation results demonstrate exceedances of the RGs as described in Section 5.0, then remediation may be required. Remediation activities, if warranted, would be described in an addendum to this RSEWP and would be conducted in accordance with applicable elements of the MARSSIM. The RSEWP Addendum would include details for any appropriate remedial action support survey(s) and subsequent FSSs.

3.3.1 Investigation Levels

ILs are media-specific or instrument-specific measurements that trigger a follow-up response, such as further investigation, if exceeded. ILs are expressed in units of the instrument's response (such as counts per minute [cpm]) that are used to indicate when additional investigations are required. ILs are established for each instrument and vary with measurement type (e.g., scan, static). ILs will be provided to the Navy, RASO, and regulatory agencies for review and approval prior to implementing field activities.

For gamma scan survey measurements collected, individual measurement results above the IL will prompt investigations that may result in the collection of biased samples or additional field measurements to determine the areal extent of the elevated activity. Potential causes of elevated gamma scanning measurements may include discrete radioactive objects (e.g., deck markers), localized soil contamination, measurement geometry effects, and NORM. Gamma scan surveys will be performed using detector systems equipped with gamma spectroscopy to provide real-time radionuclide-specific measurements. The spectra will be evaluated using region of interest (ROI) peak identification tools for the ROCs that correspond to gamma rays at 186 kiloelectron volts (keV) for ^{226}Ra; 609 keV for ^{226}Ra daughter bismuth-214 (^{214}Bi); 662 keV for ^{137}Cs; and other gamma emissions associated with the uranium and thorium decay series. The gamma scanning system will detect ^{137}Cs photons; however, individual measurements are not intended to characterize ^{137}Cs at or below the RG. In addition, gross gamma energy windows may be used to identify radiological anomalies that are not readily identified with a single gamma energy, such as the bremsstrahlung radiation from a deck marker containing ^{90}Sr.

The gamma spectroscopy detector system also may be used to assess gamma scan investigation locations using a 1-minute or greater static count and spectral analysis to compare the activity at a specific point to background. For gamma scan investigations, the net spectrum will be plotted and the critical levels assessed for ROC-specific energy ranges to find out if any activity present is above background. Critical levels, as defined in Section 6.7.1 of the MARSSIM, represent thresholds above which net counts are statistically greater than background (USEPA et al., 2000). If the gamma spectroscopy detector system static measurements identify elevated locations, then biased samples will be collected; otherwise, the static count spectra will be provided in the data reports.

The analysis of scanning data collected by the Eagle iScan^{SM} system and triggers for further investigation are described in Section 3.5.1.1. The IL for the Eagle iScan^{SM} and other field instrumentation is equal to an upper estimate of the instrument-specific and material-specific background. Specifically, the IL is the RBA mean plus three standard deviations. Appropriate instrument and site-specific gamma scan ILs for site ROC and gross gamma (i.e., full-energy spectrum) measurements will be determined following mobilization and provided to regulatory agencies. Section 3.5 describes the minimum gamma scan survey instrument requirements and the methodology to determine instrument soil scan minimum detectable concentrations (MDCs) in soil.

3.3.2 Reference Background Area

The RBA is a geographical area from which representative radioactivity measurements are conducted for comparison with measurements conducted in an impacted area. The RBA should have similar physical, chemical, radiological, and biological characteristics as the impacted area(s) being investigated and has not been identified as impacted.

The RBA north of Building 810 will be used to collect soil instrument-specific background levels. The non-radiologically impacted soil area is approximately 5,625 square feet (523 square meters). Gamma scanning and static measurements collected from the RBA will be used to develop instrument-specific critical levels and investigation levels (ILs) for GWS and gamma static measurements. The same survey methods and equipment that will be used for conducting the surveys will be used for the RBA data.

For asphalt, on-site RBAs 1, 2 and/or 4 (**Figure 3-2**), established in the *Final Background Soil Study Report, Base Realignment and Closure, Program Management Office West, Former Hunters Point Naval Shipyard, San Francisco, California* (CH2M, 2020) will be used. These paved RBAs have already been determined to be non-radiologically impacted. The asphalt RBA used will depend on actual site conditions and which RBA is most similar to the parcel asphalt.

If needed, additional reference areas may be established with the approval of the Navy. The same survey methods and equipment that will be used for conducting a survey area will be used for the background area data collection.

3.4 Radiological Investigation Design

This section describes the design of the radiological investigation, including gamma scan surveys and soil sampling. The radiological investigation design is primarily based on methods, techniques, and instrument systems in the Basewide Radiological Management Plan (TtEC, 2012) with the ultimate requirement to demonstrate compliance with the Parcel E ROD RAO (Navy, 2013). The SAP (**Appendix A**) provides additional guidance on soil sampling, chain-of-custody, laboratory analysis, and quality assurance (QA)/quality control (QC) requirements.

Two types of Parcel E soil investigations are discussed in this section to include surveys of:

- Surface and subsurface soil associated with former sanitary sewer and storm drain lines (TUs), and
- Surface soil areas associated with soil from former building sites/areas (SUs).

The investigation approach for surface and subsurface TU soil associated with former sanitary sewer and storm drain lines is divided into Phase 1 and Phase 2 components. Phase 1 includes the radiological investigation of 20 previously established TUs and Phase 2 includes the remaining 37 TUs in Parcel E. For Phase 1 TUs, durable cover material (e.g., asphalt) will be removed prior to investigation. For surface soil areas associated with soil from former building sites/areas, radiological investigation will be conducted at 122 SUs throughout Parcel E.

The principal features of the investigation protocol to be applied to the Parcel E soil TUs and SUs are discussed herein and include the following:

- Number of samples;
- Locating samples;
- Establishing radiological background;
- TU design; and
- SU design.

To the extent possible, manual data entries will be reduced or eliminated by using electronic data collection and transfer processes.

3.4.1 Number of Samples

Soil samples will be collected on a systematic sampling grid and/or from biased locations identified by the gamma scanning surveys. The number of systematic soil samples collected will be based on the guidance described in Section 5.5.2.2 of the MARSSIM (USEPA et al., 2000) using ^{226}Ra as the example basis for calculating the minimum sample frequency. Even if the MARSSIM-recommended or other statistical tests are not used to evaluate site data, these calculations serve as a basis for determining the number of samples to be collected per TU/SU. The number of biased samples will be determined based on results of scan surveys; at least one biased sample will be collected in every TU and SU.

Additional biased soil samples will be collected from locations on each RSY pad or SU that represent the ROI with highest z-score for each ROC. In total 10 ROIs have been established for radium and its progeny as well as other naturally occurring or anthropogenic gamma-emitting radionuclides that may be of interest for soil excavated from formal sanitary sewer, formal storm drain lines, formal buildings site, and building crawl space.

A minimum of 3 biased samples (or 4 biased samples when ^{232}Th is an ROC) will be collected from every RSY pad or SU scanned. Biased samples will be collected from the location of the highest gamma scan z-score for each gamma-emitting ROC, as well as from the highest scan z-score location from ROI 10 (gross gamma). For ROCs that have multiple ROIs (i.e., ^{226}Ra), the highest scan z-score among those ROIs will be selected for biased sampling. In addition, biased samples also will be collected if gamma static measurement identify elevated locations as described in Section 3.3.1. If the locations of the selected biased samples are co-located (for example, if the highest scan z-score location for ^{137}Cs and the highest scan z-score location for gross gamma are the same location), then only one biased sample will be collected at that location, as appropriate.

MARSSIM Section 5.5.2.2 defines the method for calculating the number of systematic soil samples when residual radioactivity is uniformly present throughout an SU. Therefore, determining the number of samples will be based on the following factors:

- RG for radioactivity in soil (upper boundary of the gray region [UBGR]);
- Lower boundary of the gray region (LBGR);
- Estimate of variability (standard deviation [σ]) in the reference area and the SUs;
- Shift (Δ = UBGR – LBGR);
- Relative shift $\left([\text{UBGR} - \text{LBGR}]/_{\sigma}\right)$ (see **Equation 3-1**); and
- Decision error rates for making a Type I or Type II decision error that the mean or median concentration exceeds the RG (determined via Table 5.2 of the MARSSIM).

Each of the preceding factors is addressed in the following paragraphs. Because the soil background study has been completed and published as the Final Background Soil Study Report, Base Realignment and Closure Program Management Office West, Former Hunters Point Naval Shipyard, San Francisco, California (CH2M, 2020), actual numbers of samples for SUs are based on the reference background area data. The data quality assessment (DQA) of SU data will include a retrospective power curve (based on the MARSSIM Appendix I guidance) to demonstrate that a sufficient number of samples was collected to meet the project objectives.

As stated in *Final Background Soil Study Report, Base Realignment and Closure Program Management Office West, Former Hunters Point Naval Shipyard, San Francisco, California* (CH2M, 2020), the background threshold values (BTVs) to be used for site-specific data comparisons are the off-site values listed in **Table 3-5**. The ^{226}Ra BTV of 0.861 picocurie per gram (pCi/g) is used for the number of samples calculations. The ^{226}Ra RG is defined as 1 pCi/g plus background (^{226}Ra RG = 1.861 pCi/g).

MARSSIM defines a gray region as the range of values in which the consequences of decision error on whether the ^{226}Ra concentration is less than or exceeds the RG are relatively minor. The ^{226}Ra RG of 1 pCi/g plus background (0.861 pCi/g), or 1.861 pCi/g, was selected to represent the UBGR. The LBGR is the median concentration in the SU, and the retrospective power will be determined after the survey is completed. If sufficient usable data is not available prior to performing the investigation activities, then Section 2.5.4 of the MARSSIM suggests arbitrarily selecting the LBGR as half the RG. Therefore, for this calculation, the LBGR = 0.5 x 1.861 pCi/g = 0.9305 pCi/g. Assuming the UBGR equals the RG, then Δ = 1.861 – 0.9305 = 0.9305 pCi/g for this calculation.

MARSSIM defines σ as an estimate of the standard deviation of the measured values in the SU. Because SU data will not be available until the investigation activities are completed, MARSSIM recommends using the standard deviation of the RBA as an estimate of σ. Of the four possible RBAs presented in *Final Background Soil Study Report, Base Realignment and Closure Program Management Office West, Former Hunters Point Naval Shipyard, San Francisco, California* (CH2M, 2020), the largest σ of 0.268 is conservatively used for this calculation.

The relative shift is calculated based on MARSSIM guidance (Section 5.5.2.2), as shown in the following equation:

Equation 3-1

$$\frac{\Delta}{\sigma} = \frac{(\mathrm{UBGR} - \mathrm{LBGR})}{\sigma}$$

Where: Δ = shift (UBGR – LBGR)
σ = standard deviation
UBGR = upper bound of the gray region
LBGR = lower bound of the gray region

Using the values stated above, the relative shift is calculated as 3.5.

The Roadmap provided in MARSSIM recommends that if the relative shift is greater than three (3), then the LBGR should be adjusted to provide a value between one and three for the Shift. Therefore, the LBGR will be adjusted to 1.057, which will result in a relative shift value of 3.

The minimum number of samples assumes the ^{226}Ra concentration in the SU exceeds the RG. Type I decision error is deciding that the ^{226}Ra concentration in the SU is less than the RG when it actually exceeds the RG. To minimize the potential for releasing soil with concentrations above the RG, the Type I decision error rate is set at 0.01. Type II decision error is deciding that the ^{226}Ra concentration exceeds the RG when it is actually less than the RG. To protect against remediating soil with concentrations below the RG, the Type II decision error rate is set at 0.05.

MARSSIM Table 5.3 lists the minimum number of samples to be collected in each SU and RBA based on the relative shift and decision error rates. For a relative shift of 3.0, with a Type I decision error rate of 0.01 and Type II decision error rate of 0.05, MARSSIM Table 5.3 recommends a minimum of 14 samples in each SU and RBA. Following this approach, for Phase 1, a minimum of 14 samples will be collected for every 298 yd^3 of soil (calculation for soil volume provided in Section 3.4.4.2).

The USEPA had requested that initially a minimum of 25 samples be collected in each SU until data from the RBA study is available. Because the RBA study has been completed, the minimum number of samples per SU has been determined based on the variability observed in the RBA data. A retrospective power curve will be prepared to demonstrate that the number of samples from each SU was sufficient to meet the project objectives. If necessary, additional samples may be collected to comply with the project objectives.

3.4.2 Locating Samples

Systematic soil samples will be located using Visual Sample Plan (VSP) software (or equivalent). Each TU or SU will be mapped in VSP, such that at a minimum, 14 systematic soil samples will be collected in each TU or SU. The systematic soil samples will be plotted using a random start triangular grid using the VSP software with GPS coordinates for each systematic sample.

3.4.3 Radiological Background

The RGs presented in **Table 3-5** are obtained from the Parcel E ROD (Navy 2013) and are shown as incremental concentrations above background (i.e., the *net* concentration). For the other ROCs, analytical results will be compared to the RGs or BTVs, whichever is higher. The BTVs were established in the *Final Background Soil Study Report, Base Realignment and Closure Program Management Office West, Former Hunters Point Naval Shipyard, San Francisco, California* (CH2M, 2020).

3.4.4 Phase 1 Trench Unit Design

Radiological investigations will be conducted on 20 TUs associated with former sanitary sewer and storm drain lines. The locations of the Phase 1 TUs are shown on **Figure 3-2**. The former TUs selected for Phase 1 investigation were based on their location adjacent to impacted buildings (either upstream or downstream) and consideration of the recommendations from the *Draft Radiological Data Evaluation Findings Report for Parcels B and G Soil* (Navy, 2017). The name, size, and boundary of the TUs will be based on the previous plans and reports (**Table 3-1**).

The Phase 1 TUs will be re-excavated to the previous excavation limits by making reasonable attempts to ensure accuracy in relocating the former TU boundaries (see Section 3.6.2.1). The excavated soil material will be investigated by gamma scan surveys and systematic and biased soil sample collection following the RSY process (Section 3.6.3). If the investigation results from the gamma scan surveys and results from the analyses of systematic and biased soil samples demonstrate potential exceedances of the RGs and background levels, then the material will be segregated for further evaluation as described in Section 7.2.

To address the Phase 1 radiological investigations of the former trench sidewalls and floors, former trenches will be excavated to the previous excavation limits, and then over-excavated at least an additional 6 inches outside the estimated previous boundaries of the sidewalls and 6 inches below the bottom. The exhumed over-excavated material will represent the trench sidewalls and bottom and will be gamma scan-surveyed and sampled *ex-situ*, to provide the following benefits:

- Improving the measurement quality for gamma scan surveys by controlling the measurement geometry.
  - Material thickness will not exceed 6 inches.
  - Use of large-volume sodium iodide (NaI) detectors with shielding.
  - Use of large-volume NaI detectors with spectroscopy.
- Reducing the potential safety risks associated with *in-situ* trench sidewall and bottom scanning and sampling.
- Reducing the water management required to de-water trenches to provide unsaturated material to investigate.
- Increasing assurance that all potentially impacted materials are investigated because of the inherent limitations of finding exact boundaries.

The over-excavated material (representing sidewalls and floors) will be investigated in the same manner as the original trench excavated soil by gamma scan surveys and soil sample collection through the RSY process (Section 3.6.3). The over-excavated material representing trench sidewalls and floors will be maintained as separate volumes (e.g., piles) of soil from the original trench excavated soil. If the investigation results from the gamma scan surveys and results from the analysis of systematic and biased soil samples of the over-excavated material demonstrate exceedances of the RGs and background levels, then the material will be segregated for further evaluation. An *in-situ* investigation of the trench sidewalls and floor will be performed as described in Section 3.6.3. An example of several Phase 1 TU locations with 6-inch over-excavation zones ("buffer" zone) is presented on **Figure 3-4**.

3.4.4.1 Nomenclature of Phase 1 Trench Units

The former TUs will be excavated and characterized in "batches" that will be given new unique identifiers at the time of excavation by the geologist. Excavated material representing the backfill material from former TUs will use the following identification format:

HPPE-ESU-NNNA

Where: HP = Hunters Point
PE = Parcel E
ESU = excavation soil unit
NNN = former trench unit number
A = alpha-numeric digit of each "batch" (beginning with A, in sequential order)

For example, the third "batch" of backfill TU material excavated from the former TU 152 will be identified as follows:

HPPE-ESU-152C

In this example, "ESU" identifies an excavation soil unit, "152" identifies the unit as being excavated from the former Trench Unit 152 (TU-152), and "C" represents the third unit created from excavating this former TU.

Excavated material representing the sidewalls and bottoms of former TUs will use the following identification format:

HPPE-SFU-NNNA

Where: HP = Hunters Point
PE = Parcel E
SFU = sidewall and floor unit
NNN = former trench unit number
A = alpha-numeric digit of each "batch" (beginning with A, in sequential order)

For example, the first "batch" of sidewall and floor material excavated from the former TU-152 will be identified as follows:

HPPE-SFU-152A

In this example, "SFU" identifies a sidewall and floor unit, "152" identifies the unit as being excavated from the former Trench Unit 152 (TU-152), and "A" represents the first unit created from excavating this former trench unit.

3.4.4.2 Size of Phase 1 Trench Units

RSY pads are designed to be approximately 1,000 square meters (m^2) (TtEC, 2009d, 2012). Using the assumption that material will be assayed in geometries yielding soil column thickness of 9 inches, the volume of a "batch" of excavated material (either ESU or SFU) is calculated as:

$$(1{,}000\ m^2)\ (0.0254\ m/_{inch})\ (9\ inches)\left(\frac{1.3\ yd^3}{m^3}\right) = 298\ yd^3$$

Therefore, an individual ESU or SFU volume will not exceed 298 yd^3. Converting from yd^3 to tons of soil (a more commonly used unit), the maximum "batch" size of excavated material will not exceed:

$$(298\ yd^3)\left(\frac{2{,}200\ lbs\ soil}{yd^3}\right)\left(\frac{ton}{2{,}000\ lbs}\right) \approx 328\ tons\ soil$$

This calculation assumes 2,200 pounds of loose soil per cubic yard, actual field conditions may vary from this assumption. Each former TU will be excavated and managed in no larger than approximately 298 yd^3 "batches" (i.e., ESUs or SFU) and individually stockpiled prior to radiological screening. Using a maximum size of 298 yd^3, the estimated number of expected ESUs created during the excavation of backfill from former TUs are listed in **Table 3-1**. Similarly, using a maximum size of 298 yd^3, the estimated number of expected SFUs created during the over-excavation of former TUs (representing sidewall and floor material) are listed in **Table 3-1**. The actual sizes of individual ESUs and SFUs will be determined in the field, based on the actual final excavation limits and volumes of soil material excavated from the former trenches.

3.4.5 Phase 2 Trench Unit Design

The Phase 2 TUs are listed in **Table 3-2** and depicted on **Figure 3-3**. Investigations of the Phase 2 TUs will consist of a combination of soil samples and gamma scan surveys.

Each Phase 2 TU will undergo a 100% radiological surface gamma scan of accessible areas using an appropriate instrument listed in Section 3.5. The instrument will be composed of a gamma scintillation detector equipped with a spectroscopy system that measures gross gamma counts along with radionuclide-specific measurements and is coupled to a data logger that logs the count rate data in conjunction with location. Gross gamma and gamma spectra obtained during the surface gamma scan surveys will be analyzed using ROI peak identification tools for the ROCs if the IL is exceeded. Elevated areas will be noted on a survey map and flagged in the field for verification. Manual scans using a handheld instrument may be performed to further delineate suspect areas. Biased samples will be collected from potential areas of elevated activity displaying gamma scan survey results greater than the ILs (Section 5.3.1).

Within the backfill of each previous TU boundary, VSP software (or equivalent) will be used to determine the 14 systematic soil boring locations (as determined in Section 3.4.2). A stylized graphic of an example Phase 2 TU with 14 systematic boring locations is shown on **Figure 3-5**. Each location will be cored down to approximately 6 inches below the depth of previous excavation. Each retrieved core will be scan-surveyed along the entire length of the core. Scan measurement results of the retrieved core will be evaluated to investigate the potential for small areas of elevated activity in the fill material. At least three samples will be collected from each of the 14 borings, for a total of 42 samples per previous TU boundary. A sample will be collected from the top 6 inches of the original fill surface material, and a second sample will be collected from the 6 inches of material just below the previous excavation depth, representing the trench bottom. A third sample will be collected from the core segment with the highest scan reading that was not already sampled. The anticipated number of subsurface soil samples is shown in **Table 3-2**; however, additional locations or samples may be required based on the evaluation following analysis of RBA data.

In addition, systematic cores will be placed every 50 linear feet on each trench sidewall in order to collect samples from locations representative of the trench sidewalls. The systematic boring locations will be located approximately 6 inches outside of the previous sidewall excavation limits and will extend 6 inches past the maximum previous excavation depth on both sidewalls in every trench. In the same fashion described in the previous paragraph, core sections will be retrieved and scan-surveyed along the entire length of the core. At least three samples will be collected from each of the boring locations. The projected number of borings and soil samples obtained from sidewall material is presented in **Table 3-2**. The typical sample locations representing the TU sidewalls are shown on **Figure 3-5**. The subsurface soil sampling process is detailed in Section 3.6.4.1. The soil samples will be submitted to the offsite analytical laboratory for analysis according to the SAP (**Appendix A**).

3.4.6 Former Building Sites

Radiological investigations will be conducted in 122 SUs associated with soil from building sites where surface soil scanning and sampling was previously conducted (**Figure 3-6**). The name, size, and boundary of the SUs will be based on the previous plans and reports (**Table 3-3**).

Each surface SU will undergo a 100 % radiological surface gamma scan of accessible areas using an appropriate instrument listed in Section 3.5. The instrument will be composed of a gamma scintillation detector equipped with spectroscopy coupled to a data logger that logs the resultant data in conjunction with location. Gross gamma and gamma spectra obtained during the surface gamma scan surveys will be analyzed using ROI-peak identification tools for the ROCs. Elevated areas will be noted on a survey map and flagged in the field for verification. Manual scans using a handheld instrument may be performed to further delineate suspect areas in the SU. Biased samples will be collected from potential areas of elevated activity displaying gamma scan survey results greater than the IL (Section 5.3.1).

Following the completion of the gamma scan surveys, the SU area will be plotted using VSP software (or equivalent) to determine the location of systematic samples. A stylized graphic of an example SU with 14 systematic sample locations is shown on **Figure 3-4**. The surface soil sample collection process is detailed in Section 3.6.5.1. The soil samples collected from each SU will be submitted to the off-site analytical laboratory for analysis according to the SAP (**Appendix A**).

3.5 Instrumentation

Radiation instruments, consistent with Basewide Radiological Management Plan (TtEC, 2012), have been selected to perform measurements in the field. Specifics related to radiological investigation implementation are provided in Section 3.6. The laboratory instruments used to analyze the soil samples and the associated standard operating procedures (SOPs) for calibration, maintenance, testing, inspection, and QA/QC are discussed in the SAP (**Appendix A**).

The following instrumentation information is included in this section:

- Soil gamma scanning instruments
- Instrument detection calculations
- Calibration
- Daily performance checks

Instruments that are expected to be used during fieldwork for activities other than soil gamma scan surveys are described in Section 6.5.

3.5.1 Soil Gamma Scanning Instruments

The gamma scanning survey instruments should be selected to provide a high degree of defensibility and based on their capability to measure and quantify gamma radiation and position using the best available technology. The primary gamma scanning instrument that will be used during soil scan surveys of excavated trench soil on the RSY pads and soil area SUs will be the Eagle iScan^{SM} overland gamma scanning system that consists of a 4-liter (3-inch by 5-inch by 16-inch) NaI gamma scintillation detector towed behind a utility vehicle and coupled to a

DigiBase (photo multiplier tube and multi-channel analyzer) with automated data logging using MAESTRO Multichannel Analyzer Emulation Software. Both gross gamma and gamma spectral measurements will be collected simultaneously during the gamma scan along with a date and time stamp. In addition to automated radiological data collection, the position of the detector will be logged using a global positioning system (GPS). The MAESTRO software and GPS data will be managed using a personal computer or tablet.

For gamma scan surveys of retrieved cores, the Eagle iScan^{SM} handheld system that consists of a 3-inch by 3-inch NaI detector coupled to a DigiBase (photo multiplier tube and multi-channel analyzer) with automated data logging using MAESTRO Multichannel Analyzer Emulation Software. The instruments that are expected to be used during fieldwork are listed in **Table 3-6**.

3.5.1.1 Eagle iScan Gamma Scan Data Analysis

The data collected during the gamma scan using the Eagle iScan^{SM} towed or handheld systems are evaluated as follows. A tiered approach is used during data review for the Eagle iScan^{SM} towed or handheld systems data to identify areas requiring additional surveys and biased samples as described in the second stage of the gamma count rate surveys. The gamma spectra will be evaluated using ROI-peak identification tool capabilities in the MAESTRO software for the ROCs that correspond to gamma rays at 186 kiloelectron volts (keV) for ^{226}Ra, 609 keV for ^{226}Ra daughter ^{214}Bi, and other gamma emissions associated with the naturally-occurring uranium and thorium decay series (if necessary). In addition, gamma energy windows will be used to identify radiological anomalies that are not readily identified with a single gamma energy.

Results of the surveys conducted with GPS data will be plotted using GIS software and areas observed to have a radiological signature greater than the ILs described in Section 3.3.1 shall be physically investigated.

3.5.2 Instrument Detection Calculations

The equations to calculate efficiencies, MDCs, and minimum detectable count rates (MDCRs) at HPNS are based on the methodology and approach used in MARSSIM (Chapter 6) and Nuclear Regulatory Commission (NRC) Regulation 1507 (NUREG-1507), *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions* (NRC, 1998) (Chapter 6). The instrument equations in this section may be used to calculate adjustments if the changes are approved in writing by a Certified Health Physicist before initial use. The following calculations are examples intended to illustrate the calculation approach.

3.5.2.1 Gamma Surface Activity

Estimating the amount of radioactivity that can be confidently detected using field instruments is performed by adapting the methodology and approach used in MARSSIM (Section 6.7.2.1) and NUREG-1507 (NRC, 1998) (Section 6.8.2) for determining the gamma scan MDC for photon-emitting radionuclides.

The scan MDC (in pCi/g) for areas is based on the area of elevated activity, depth of contamination, and the radionuclide (energy and yield of gamma emissions). The computer code Microshield can be used to model expected exposure rates from the radioactive source at the detector probe

NaI crystal and includes source-to-detector geometry. The geometry is used to calculate the total flow of photons incident upon the detector crystal, called the gamma fluence rate, ultimately corresponding to an exposure rate that is associated with a count rate in the instrument.

The amount of radiation the detector crystal is exposed to from the modeled source is used to determine the relationship between the detector's net count rate and the net exposure rate (counts per minute per microroentgen per hour [cpm/μR/hr]).

3.5.2.2 Gamma Scan Minimum Detectable Concentration

The minimum detectable number of net source counts in the scan interval is given by s_i, which can be arrived at by multiplying the square root of the number of background counts (in the scan interval) by the detectability value associated with the desired performance (as reflected in d'), as shown in **Equation 3-2** (Equation 6-8 of MARSSIM):

Equation 3-2

$$s_i = d'\sqrt{b_i}$$

Where: d' = index of sensitivity (α and β errors [performance criteria])
b_i = number of background counts in scan time interval (count)
i = scan or observation interval (seconds)

For scanning at HPNS, the required rate of true positives will be 95 %, and the false positives will be 5 %. From Table 6.5 of MARSSIM, the value of d', representing this performance goal, is 3.28. The MDCR, in cpm, is calculated by **Equation 3-3** (Equation 6-9 of MARSSIM):

Equation 3-3

$$MDCR = s_i(60/i)$$

Where: s_i = minimum detectable number of net source counts in the scan interval
i = scan or observation interval (seconds)

Next, the MDCR is used to calculate the *Surveyor* MDCR by applying a surveyor efficiency factor shown in **Equation 3-4** (Page 6-45 of MARSSIM):

Equation 3-4

$$MDCR_{surveyor} = \frac{MDCR}{\sqrt{p}}$$

Where: MDCR = minimum detectable count rate
p = surveyor efficiency

After a surveyor efficiency is selected, the relationship between the $\mathrm{MDCR}_{surveyor}$ and the radionuclide concentration in soil (in becquerels per kilogram or pCi /g) is determined. This correlation requires two steps: (1) establish the relationship between the detector's net count rate and net exposure rate (cpm / μR /hr), and (2) determine the relationship between the radionuclide contamination and exposure rate. The relationship between the detector's net count rate and the net exposure rate may be determined analytically, using reference guidance documents, or obtained from the detector manufacturer. Modeling (using Microshield) of the source area is used to determine the net exposure rate produced by a given concentration of radionuclides at a specific distance above the source. The scan MDC is calculated by **Equation 3-5** (Page 6-45 of MARSSIM):

Equation 3-5

$$Scan\ MDC = \left(\frac{MDCR_{surveyor}}{\varepsilon_{inst}}\right) \times \left(\frac{radionuclide\ concentration\ [pCi/g]}{exposure\ rate\ [\mu R/hr]}\right)$$

Where: $MDCR_{surveyor}$ = minimum detectable count rate surveyor
ε_{inst} = instrument efficiency (cpm /μR /hr)
radionuclide concentration = modeled source term concentration (pCi/g)
exposure rate = result of model (μR /hr)

3.5.2.3 Example Gamma Scan Minimum Detectable Concentrations

An example a priori scan MDC calculation is provided herein for ^{226}Ra using the Perma-Fix Eagle iScan^{SM} Handheld 3-inch by 3-inch Alpha Spectra NaI(Tl) detector. This example assumes a background level of 18,000 cpm and 95% correct detections and 5% false positive rates resulting in a d' of 3.28. A scan rate of 0.5 meter per second (m/s) (19.7 inches per second) provides an observation interval of 2 seconds (based on a diameter of approximately 1 m for the modeled area of elevated activity). The $MDCR_{surveyor}$ was then calculated assuming a surveyor efficiency (ρ) of 1 (assumes automated data logging). The scan MDC is calculated as follows:

$$s_i = (3.28)\sqrt{(18{,}000)([2\ \text{sec}]/[60\ \text{sec}])} = 80\ counts$$

$$MDCR = (80)\left(\frac{60\ sec}{2\ sec}\right) = 2{,}410\ cpm$$

$$MDCR_{surveyor} = \frac{(2{,}410\ cpm)}{\sqrt{1}} = 2{,}410\ cpm$$

The relationship between the detector's net count rate and the net exposure rate has been obtained from the detector manufacturer and is 2,300 cpm/μR/hr. The relationship between the radionuclide contamination and exposure rate has been determined by modeling (using Microshield) the source area to determine the net exposure rate produced by a given concentration of radionuclides at a specific distance above the source. The Microshield Version 11.20 model has a source activity of 1 pCi/g of ^{226}Ra, a circular area of elevated activity of 1 m^2, a contaminated zone depth of 15 centimeters (cm) (6 inches), and a soil density of 1.6 grams per cubic centimeter. The modeling code determined an exposure rate at the detector height (dose point) of 10 cm (4 inches) above the source to be 1.130 μR/hr. The scan MDC for this source geometry is calculated as follows:

$$Scan\ MDC = \left(\frac{2{,}410\ \text{cpm}}{2{,}300\ \text{cpm}/\mu\text{R/hr}}\right) \times \left(\frac{1.0\ p\text{Ci/g}}{1.130\ \mu\text{R/hr}}\right) = 0.93\ \text{pCi/g}$$

Additional a-priori determinations are provided in **Table 3-7**. The MicroShield model parameters are identical to those described in the previous example, using either ^{226}Ra with a concentration of 1 pCi/g, or ^{137}Cs with a concentration of 0.113 pCi/g. Note that the measurement geometry and parameters modeled are meant to illustrate an assumption for the calculation. Contamination, if present, may not exist in the same modeled configuration, and the modeled scan MDCs may not apply. As shown in **Table 3-7**, the calculated gamma scan sensitivity for ^{137}Cs is not expected to be sufficient to detect ^{137}Cs at or below the RG. Therefore, compliance with the Parcel E ROD RAO for ^{137}Cs will be based on the analytical data from soils sampling.

After field mobilization, MDC calculations will be revised using actual site-specific and instrument-specific data. Observed MDCs will be provided to regulatory agencies and will be documented in the RACR.

3.5.3 Calibration

Portable survey instruments will be calibrated annually at a minimum, in accordance with American National Standards Institute (ANSI) N323a-1997 Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments (ANSI N323) (ANSI, 1997), or an applicable later version. Instruments will be removed from service on or before calibration due dates for recalibration. If ANSI N323 does not provide a standard method, then the calibration facility should comply with the manufacturer's recommended method.

3.5.4 Daily Performance Checks

Before use of the portable survey instruments, calibration verification, physical inspection, battery check, and source-response check will be performed in accordance with SOP RP-108, *Count Rate Instruments,* and SOP RP-109, *Dose Rate Instruments*, which are provided in the RPP (**Appendix C**). Portable survey instruments will have a current calibration label that will be verified daily prior to use of the instrument.

Physical inspection of the portable survey instrument will include the following:

- General physical condition of the instrument and detector before each use;
- Knobs, buttons, cables, connectors;
- Meter movements and displays;
- Instrument cases;
- Probe and probe windows; and
- Other physical properties that may affect the proper operation of the instrument or detector.

Any portable survey instrument or detector having a questionable physical condition will not be used until problems have been corrected. A battery check will be performed to ensure that sufficient voltage is being supplied to the detector and instrument circuitry for proper operation. This check will be performed in accordance with the instrument's operations manual. The instrument will be exposed to the appropriate (alpha, beta, gamma) check source to verify that the instrument response is within the plus or minus 20 % range determined during the initial response check. The calibration certificates and daily QA/QC records for each instrument used and the instrument setup test records will be provided in the project report.

If any portable survey instrument (or instrument and detector combination) having a questionable physical condition that cannot be corrected, fails any of the operation checks stated in SOP RP-108, *Count Rate Instruments*, or SOP RP-109, *Dose Rate Instruments* (**Appendix C**), or has exceeded its annual calibration date without PRSO approval, then the instrument will be put in an "out of service" condition. An "out of service" tag (or equivalent) will be placed on the instrument and the instrument will be secured in a separate area such that the instrument cannot be issued for use. The PRSO and Radiological Protection Technician (RPT) and their respective supervisors will be notified immediately when any survey instrumentation has been placed "out of service". Instruments tagged as "out of service" will not be returned to service until all deficiencies have been corrected. The results of the daily operation checks, previously discussed, will be documented.

3.6 Radiological Investigation Implementation

This section describes the implementation of radiological investigations for soil.

3.6.1 Premobilization Activities

Before initiating field investigations, several premobilization steps will be completed to ensure that the work can be conducted in a safe and efficient manner. The primary premobilization tasks include training of field personnel and procurement of support services.

A list of the various support services that are anticipated to be required are as follows:

- Radiological analytical laboratory services;
- Radiological screening and support subcontractor;
- Site work subcontractor;
- Drilling subcontractor;
- Civil surveying subcontractor;
- Utility location subcontractor; and
- Transport (trucking) subcontractor (only if necessary).

3.6.1.1 Training Requirements

Any non-site-specific training required for field personnel will be performed before mobilization to the extent practical. Training requirements are outlined in Section 6. Medical examinations, medical monitoring, and training will be conducted in accordance with the APP/SSHP and Section 6 requirements. In addition to health and safety-related training, other training may be required, as necessary, including but not limited to:

- Aerial Lift (for personnel working from aerial lifts)
- Fall Protection (for personnel working at heights greater than 5 feet)
- Equipment as required (e.g., fork-lift, skid steer, loader, backhoe, excavator)

3.6.1.2 Permitting and Notification

Before initiation of field activities for the radiological investigation, EIP will notify the Navy Remedial Project Manager (RPM), Resident Officer in Charge of Construction (ROICC), Radiological Affairs Support Office (RASO), and HPNS security as to the nature of the anticipated work. Any required permits to conduct the fieldwork will be obtained before mobilization. EIP will notify the California Department of Public Health (CDPH) at least 14 days before initiation of activities involving the Radioactive Material License.

3.6.1.3 Pre-construction Meeting

A pre-construction meeting will be held before mobilization of equipment and personnel. The purpose of the meeting will be to discuss project-specific topics, roles and responsibilities of project personnel, project schedule, health and safety concerns, and other topics that require discussions before field mobilization. Representatives of the following will attend the pre-construction meeting:

- Navy (RPM, RASO, ROICC, and others as applicable)
- EIP (Project Manager, Project QC Manager, Project Radiation Safety Officer, and Site Safety and Health Officer)
- Subcontractors, as appropriate

3.6.2 Mobilization Activities

Mobilization activities will include site preparation, movement of equipment and materials to the site, and orientation and training of field personnel. At least 2 weeks before mobilization, the appropriate Navy personnel, including the Navy RPM and ROICC and Caretaker Site Office, will be notified regarding the planned schedule for mobilization and site remediation activities. Upon receipt of the appropriate records and authorizations, field personnel, temporary facilities, and required construction materials will be mobilized to the site.

The temporary facilities will include restrooms, hand-washing stations, and one or more secure storage (Conex) boxes for short-term and long-term storage of materials, if needed. The proposed project facilities (Soil Processing Area, Construction Equipment Refueling Area, and Stabilized Construction Entrance/Exit) are presented on **Figure 3-7**.

The applicable activity hazard analysis (AHAs) forms will be reviewed prior to starting work. All equipment mobilized to the site will undergo baseline radioactivity surveys in accordance with Section 7. Surveys will include directs scans, static measurements, and swipe samples. Equipment that fails baseline surveying will be removed from the site immediately.

3.6.2.1 Locating and Confirming Boundaries

The first step to begin the radiological investigations is locating and marking the boundaries of the former TUs and SUs. This will be accomplished by using best management practices (BMPs) to identify boundaries and depths of the former TUs and SUs based on the previous TtEC reports (e.g., survey reports, drawings, and sketches), field observations (such as GPS locations from geo-referencing, borings, and visual inspection), and as-built records. Once the boundaries are located, the areas will be marked with paint and/or pin flags.

3.6.2.2 Site Preparation

After boundary location and mark-outs are completed, the following steps will be implemented to prepare the site for investigation and facilitating access.

- A radiologically controlled area (RCA) will be established around work areas and delineated with temporary fencing or caution tape, or equivalent. Appropriate warning signage will be posted and access control points will be established and maintained. Radiological screening of personnel, equipment, and materials will be required when exiting the RCA. The RCA will be posted consistent with the requirements of the Radiation Protection Plan and SOP RP-102, *Radiological Postings* (**Appendix C**). Routine surveys and inspections consisting of dose rate measurements and visual inspections will be conducted along the fence line. Surveys will be conducted to ensure that dose readings in accessible areas that could negatively affect the public or environment do not change. Any breaches in the fence during site activities will be repaired.
- Stormwater, sediment, and erosion control measures will be implemented to prevent soil from entering and leaving the site as detailed in SWP (**Appendix E**).
- Dust control methods and air monitoring will be implemented during intrusive activities as detailed in DCP (**Appendix F**).
- An independent field survey to identify, locate, and mark potential underground utilities or subsurface obstructions will be conducted by a third-party utility locator subcontractor following a review of existing utility drawings of the affected areas. The survey will be conducted over the known or suspect areas where underground utilities may exist using ground-penetrating radar or electromagnetic instrumentation. Underground Service Alert will be contacted at least 72 hours before initiating intrusive activities. The results of the geophysical survey will be compared to the available historical drawings and combined with Underground Service Alert markings (if any) to identify locations of underground utilities. Additionally, a visual survey of the area to validate the chosen location will also be conducted. Colored marking paint (or stakes or equivalent) will be used to mark identified utilities, if any, within the proposed work area. A minimum of 2 feet from the closest observed utility will be maintained to prevent accidental exposure to the utility, based on the utility hazard or importance. Utility lines encountered will be assumed active, unless specifically determined to be inactive through consultation with the subject utility company and with the Navy Caretaker Site Office representative, ROICC, and RPM.
- For both Phase 1 TUs and Phase 2 TUs, the asphalt cover (where present) will be removed to expose the target soils. The exact horizontal boundaries of a previous excavation may be difficult to determine; therefore, to provide access to the TU, and to account for regrading, an additional 1 foot of asphalt material on both sides of the historical trench excavation boundary will be removed to allow for a sufficient buffer for excavation of trench materials (Phase 1 TUs) and access for the surface gamma scan (Phase 2 TUs). After the asphalt cover is removed, attempts will be made to confirm the delineation between fill materials and native soils by reviewing cut-and-fill drawings and visual inspections.
- Asphalt cover materials that are removed will require release surveys prior to off-site

disposal. Release surveys of the materials will be performed according to SOP RP-105, *Unrestricted Release Requirements* (**Appendix C**).

3.6.3 Phase 1 Trench Unit Investigation

Once all site preparation activities previously described are completed, TU investigation activities will commence. Each former TU will be excavated to the original excavation limits and evaluated in a maximum volume of approximately 298 yd^3 per ESU. The excavated material will then undergo radiological assay following the RSY pad process as described in the following sections. One hundred percent of the Phase 1 ESU soils will undergo scan surveys using gamma spectroscopy equipment in the RSY pad process. Details on the scanning instrumentation are presented in Section 3.5.

After the excavation to the original trench limits has been completed, at least 6 inches of the sidewalls and trench floor material (outside the estimated previous boundaries) will be excavated. This exhumed over-excavated material (SFU) will be maintained separate from the backfill volumes (ESU) and will represent the trench sidewalls and bottom. The over-excavated material (SFU) will be investigated in the same fashion as the excavated soil (ESU) methodology by gamma scan surveys and soil sample collection through RSY process. Following completion of scanning activities and sampling, the ESU and SFU material will either be returned to the same trench that the material originated from or will be segregated for further investigation.

3.6.3.1 Radiological Screening Yard Pad Process

The objective of the processing activities on the RSY pads is to characterize the material. Excavated TU material will be assayed using the previously applied RSY process. Each RSY pad will be gamma scan surveyed to characterize the radiological conditions of each pad prior to use. The initial gamma survey will be performed using the Eagle iScan^{SM} overland (towed behind a utility vehicle) gamma detection system in the manner described in this section to survey excavated TU materials. Results of the initial survey will be evaluated as described in Section 3.5.1.1. Each RSY pad dataset will be evaluated against the RBA ILs to confirm suitability. If gamma scan surveys indicate areas of potentially elevated activity above the ILs, then an investigation of the potential area of elevated activity will be initiated.

At a minimum, the gamma scan data will be evaluated and biased soil samples will be collected. A minimum of 3 biased samples (or 4 biased samples when ^{232}Th is an ROC) will be collected from each RSY pad. Biased samples will be collected from the location of the highest gamma scan z-score for each gamma-emitting ROC, as well as from the highest scan z-score location from ROI 10 (gross gamma). For ROCs that have multiple ROIs (i.e., ^{226}Ra), the highest scan z-score location among those ROIs will be selected for biased sampling. If the locations of the selected biased samples are co-located (for example, if the highest scan z-score location for ^{137}Cs and the highest scan z-score location for gross gamma are the same location), then only one biased sample will be collected at that location, as appropriate. In addition, biased samples also will be collected if gamma static measurement identify elevated locations as described in Section 3.3.1.

If no existing RSY pads are available for use, then new pads will be constructed. RSY pads will be constructed with a size limit of 1,000 m^2. Prior to constructing the pad, a gamma scan and appropriate gamma static survey will be conducted of the underlying ground surface to establish a baseline and to determine if there is radiological contamination present. If the baseline gamma scan and gamma static survey of the ground surface identifies areas where the count rate exceeds the instrument-specific IL, then the area will be flagged. Flagged areas will be further investigated by a spectral analysis using the Eagle iScan^{SM}, or equivalent, or by soil sampling, if the ground surface is soil. If results indicate ROC concentrations above the critical level (for spectral analysis) or release criteria (for soil samples), then appropriate remediation or relocation of the RSY pad may be necessary and will be determined in consultation with the Navy. Once the RSY area has been cleared of potential material generating elevated gamma scanning measurements, the RSY pad will be constructed and surveyed as follows:

- Area will be covered with 10-mil plastic sheeting (or equivalent).
- Perimeter of the RSY pads will be bermed with hay bales (or equivalent) to prevent run-on and run-off during precipitation events.
- If the existing surface is uneven and/or consists of materials with different radiological characteristics (e.g., soil and asphalt), then a 6-inch-thick buffer of clean import fill, and/or rock (or equivalent) will be laid across the plastic. The buffer material will be visually inspected to ensure it is free of debris/organic matter and of sufficient clay content to be readily compactable. If the existing surface is even and consists of similar materials, then a buffer layer will not be used.
- If a buffer soil layer is used, then it will be compacted via a minimum of four passes with an excavator or similar tracked machine. This will prevent damage to the plastic sheeting when the excavated soil is added or removed.
- Baseline radiological survey of the constructed RSY pad will be performed prior to the initial placement of excavated soil. After the baseline survey of the buffer soil (if required), plastic sheeting will be placed on the buffer soil later to prevent cross-contamination from the placement of excavated soil.
- A post-use gamma scan survey will be performed following removal of the RSY screened soil, and again following removal of the RSY pad itself, to verify that cross-contamination of the buffer soil and the underlying surface did not occur. If the gamma scan survey confirms that no cross-contamination occurred, then the buffer soil may be disposed as non-contaminated material or may be reused elsewhere at HPNS with Navy concurrence.

Following completion of the initial gamma scan survey and acceptance of each RSY pad for use, excavated TU materials will be transported to an RSY pad and spread a maximum of 9 inches thick for processing. Processing activities in the RSY pads include gamma scan surveys, using a large-volume gamma scintillator equipped with spectroscopy; systematic and biased sampling and analyses; performing investigation activities (as necessary); radiologically clearing the materials for either reuse or disposal; and loading of the materials for transport off the RSY pads. Material that meets the RGs identified in **Table 3-5** will be used as backfill material or shipped off site as non-radiological waste. Before initiating excavation activities at each TU, existing RSY pads will be identified for use or new pads will be constructed. Transport routes between the TU and the selected RSY pads will be established and approved by the Navy before initiating excavation activities at each TU.

3.6.3.2 Transfer of Excavated Soil for Processing

Excavated TU materials will be transported to the RSY pad by dump truck. Excavated soil entering an RSY must be accompanied by a truck ticket (paper or digital), to facilitate transfer of the material for radiological processing along a designated truck route. This ticket will provide the RSY staff with the following information:

- Location of excavation, including former TU name;
- TU sidewall or floor from which material was excavated (if applicable);
- Load number;
- Estimated volume of soil; and
- Date and time of excavation.

The RSY personnel will direct the driver to the appropriate RSY pad for soil placement. The truck ticket will be amended with the assigned unique RSY pad number for tracking purposes. Placement of soil on a RSY pad in the RSY will continue until the soil placed on the RSY pad reaches capacity as identified by the RSY Manager (or designee) and is ready for processing. Each individual 298 yd^3 TU stockpile will be loaded onto the RSY pad, spread out, and leveled to a maximum depth of 9 inches for investigation.

3.6.3.3 General Process

The RSY process will include gamma scans over 100% of the surface area, systematic soil sampling, and biased soil sampling. Gamma scans of the spread soil will be performed using the Eagle iScan^{SM} overland gamma detection system as described in Section 3.5.

Using the Eagle iScan^{SM} overland system (or equivalent), the scans will be performed by scanning straight lines at a not-to-exceed rate of 0.5 m/s with a consistent detector distance from the soil surface (approximately 4 inches above the surface). Generally, RSY pad lift will be gamma scanned as follows:

- Begin with the detector positioned in the southwest corner of the RSY pad at a height of approximately 4 inches above the surface. Orient the system to face north and initiate data collection (detector is automatically logging radiation readings and GPS is automatically logging position readings) so that the system is recording at a rate of one reading per second (or other, as determined by the project Health Physicist).
- Move the detector in the north direction at a not-to-exceed speed of 0.5 m/s.
- Once the detector has reached the edge of the pad, turn the system around (now facing south) and offset the next detector path by the appropriate offset based on the instrument's detector size (e.g., field of view), to allow for a small overlap in the detector field of view.
- Move the detector in the southern direction at a not-to-exceed speed of 0.5 m/s.
- Repeat these steps until the soil on the RSY pad area has been scan-surveyed.

The above process assumes the RSY area is positioned such that the sides align with north, south, east, west directions.

The data collected during the gamma scan using the Eagle iScan℠ are evaluated as described in Section 3.5.1.1. If gamma scan surveys indicate areas of potentially elevated activity in soil above the ILs (Section 3.3.1), then an investigation of the potential area of elevated activity will be initiated. At a minimum, the gamma scan data will be further evaluated and biased soil samples will be collected. A biased soil sample will be collected from the approximate location of the highest elevated gamma scan survey measurement. If areas displaying elevated activity are collocated, then an attempt will be made to locate the area with the highest gamma scan results and designate it as the biased sample location to represent the collocated elevated areas. Material with potentially elevated concentrations will remain segregated until completion of the investigation activities. If soil sampling indicates areas of potentially elevated soil above the RGs and contamination in the soil is confirmed, and if the soil material originates from an SFU, then the Navy will be immediate notified to determine the path forward.

Each 1,000 m^2 RSY pad area will be plotted using VSP software (or equivalent) to determine the location of the 14 systematic soil samples. The systematic soil samples will be plotted using a random start triangular or square grid using the VSP software. Soil samples will be collected from the surface at a depth of 0 to 9 inches. The technique for locating systematic samples is provided in Section 3.4.2. Soil samples will be containerized and submitted to off-site laboratory with appropriate chain-of-custody documentation as established in the SAP (**Appendix A**).

Soil processed by the RSY process will be temporarily staged in a storage bin or a stockpile pending evaluation of off-site analytical results and Navy approval for either off-site disposition or on-site reuse. If elevated sample results are identified by off-site analysis, then EIP will notify the Navy and determine a suitable soil rescreening process using an RSY pad.

Following completion of scan surveys, sampling, and any potential investigation activities, the excavated material will be returned to the same trench that the material originated from.

3.6.4 Phase 2 Trench Unit Investigation

Once all site preparation activities previously described are completed, Phase 2 TU investigation activities will commence. Investigations of the 37 Phase 2 TUs will consist of a combination of soil samples and gamma scan surveys.

Following removal of any durable cover (where applicable), gamma scan surveys of the surface soil will be performed using the Eagle iScan℠ or one of the gamma detectors listed in **Table 3-6** (or equivalent). The scan surveys will generally be performed using the same protocols and methods as those for the RSY pads. The accessible surface of the Phase 2 TUs will be 100% gamma scan surveyed using a large-volume gamma scintillator, equipped with real-time gamma spectroscopy and data logging coupled to a GPS unit.

Data sets will be transferred from the data logger onto a personal computer to create spreadsheets and to map the gamma scan survey results. Data obtained during the surface gamma scan surveys, will be analyzed to identify areas where surface radiation levels appear to be greater than the gross gamma ILs.

If gamma scan surveys indicate areas of potentially elevated activity above the ILs (Section 3.3.1), then an investigation of the potential area of elevated activity will be initiated. At a minimum, the gamma scan data will be further evaluated to assess individual radionuclide spectral measurements and biased soil samples will be collected. A minimum of 3 biased samples (or 4 biased samples when ^{232}Th is an ROC) will be collected in each SU. Biased samples will be collected from the location of the highest gamma scan z-score for each gamma-emitting ROC, as well as from the highest scan z-score location from ROI 10 (gross gamma). For ROCs that have multiple ROIs (i.e. ^{226}Ra), the highest scan z-score among those ROIs will be selected for biased sampling. If the locations of the selected biased samples are co-located (for example, if the highest scan z-score location for ^{137}Cs and the highest scan z-score location for gross gamma are the same location), then only one biased sample will be collected at that location, as appropriate. In addition, biased samples will also be obtained if gamma static measurement identify elevated locations as described in Section 3.3.1. If areas displaying elevated activity are collocated, then an attempt will be made to locate the area with the highest gamma scan results and designate it as the biased sample location to represent the collocated elevated areas.

The 14 systematic boring locations within each TU boundary will be used to collect soil samples down to approximately 6 inches below the depth of previous excavation. Soil samples will be collected as described in Section 3.6.4.1. Sanitary sewer and storm drain lines were sometimes installed on bedrock. In these situations, samples of bedrock will not be collected. If refusal is encountered within 6 inches of the expected depth of the trench, then the soil sample will be collected from the deepest section of the core. If refusal is encountered more than 6 inches above the expected depth of the trench, then the sample location will be moved to avoid the subsurface obstruction.

To acquire three samples from each boring, one surface and one floor sample will be collected from each sample core. The sample cores will be scanned for gamma radiation along the entire length of each core using the Perma-Fix Eagle iScan℠ handheld 3-inch by 3-inch NaI (or equivalent) equipped with gamma spectroscopy. Scan measurement results will be evaluated against the IL to identify core section with elevated gamma radiation. Core sections that exceed the IL will have biased soil samples collected to investigate the potential for small areas of elevated activity in fill. If no core section exceeds the IL, a biased sample will be collected from the core segment with the highest gamma scan reading that was not already sampled, for a total of at least three samples from each core.

Additionally, systematic samples will be collected from sidewall locations every 50 linear feet, representative of each of the trench sidewalls. The boring locations will be located within 1 meter of the previous sidewall excavation limits and will extend to the maximum previous excavation depth. In the same action described in the previous paragraph, core sections will be retrieved, scanned, and sampled such that at least three samples will be collected from each of the boring locations. An example graphic showing the sample locations representing the TU sidewalls is provided on **Figure 3-5**.

If GPS reception is available, then soil sample locations will be position-correlated with GPS data and recorded. If GPS reception is not available, then a reference coordinate system will be established to document gamma scan measurement results and soil sample locations. The reference coordinate system will consist of a grid of intersecting lines referenced to a fixed site location or benchmark. If practical, the GPS coordinates of the fixed location or benchmark will be recorded.

3.6.4.1 Subsurface Soil Sample Collection

Subsurface soil samples will be collected by following the *Soil Sampling* SOP, included in **Appendix A**. Subsurface soil samples will be collected using a conventional drilling rig or a direct-push rig to collect samples with thin-walled tube sampling or split-spoon sampling. When needed, other methods may be considered and applied. Specific sampling methods used will be documented in the field, and deviations from the RSEWP will be described in the final report. Disposable sampling equipment will be used whenever practical and will be disposed of immediately after use. If reusable sampling equipment is used, then decontamination between sampling locations will be performed following the *Decontamination of Personnel and Equipment* SOP, included in **Appendix A**. Generally, drilling and retrieving the boring samples using the thin-walled tube method will be as follows:

- Using a drilling rig, a hole is advanced to the desired depth. The samples are then collected following the ASTM International (ASTM) D 1587 standard.
- The thin-walled sample tube is lowered into the hole so that the base of the sample tube rests on the bottom of the hole. The sample tube is advanced by a continuous, relatively rapid downward motion. The sample tube is withdrawn from the soil formation as carefully as possible to minimize disturbance of the sample. To obtain enough sample volume for subsequent laboratory analysis, a sample tube with an internal diameter of 3 inches may be required.
- Upon removal of the sample tube from the ground, drill cuttings in the upper end of the tube are removed, and the upper and lower ends of the tube are sealed. The sample tube will be turned over to the project geologist and radiation technician for sample preparation, radiological surveys, and containerization. Once retrieved from the hole, the tube is carefully cut open to maintain the material in the tube.

Generally, drilling and retrieving the boring samples using the split-spoon sampling method will be performed as follows:

- Using a drilling rig, a hole is advanced to the desired depth. The samples are then collected following the ASTM D 1586 standard.
- The split-spoon sampler is lowered into the hole and driven to a depth equal to the total length of the sampler; typically, this is 24 inches. The sampler is driven down using a standard weight or "hammer". To obtain enough sample volume for subsequent laboratory analysis, a sample tube with an internal diameter of 3 inches may be required.
- Upon removal of the split-spoon sampler from the ground, the split-spoon sampler will be turned over to the project geologist and radiation technician for sample preparation, radiological surveys, and containerization. Once retrieved from the hole, the sampler is carefully split open to maintain the material in the tube.
- Once the split-spoon sampler has been cut open or the core has been split open, soil examination and sample collection will occur as follows:

  - The geologist log will log the soil boring to provide accurate and consistent descriptions of soil characteristics. Soil boring logs will be maintained according to the *Logging of Soil Borings* SOP, included in **Appendix A**.
  - The sample for radiological analyses will be mixed in the field by breaking the sample into small pieces and removing gravel. The depth, recovery position, and scan measurement information will be correlated to each sample extracted from the core.
  - A minimum of 200 grams of soil (approximately 1 cup) are required to complete all required analyses, or 400 grams if the sample is selected as a field duplicate. If sample size requirements are not met by a single sample collection, then additional sample volume may be obtained by collecting a sample from below the original sample location within the core and compositing the sample.
  - The entire mixed sample will be placed in the designated laboratory sample container and the range of soil depths included in the sample will be recorded in the field logbook.
- Samples will be identified, labeled, and cataloged according to the SAP (**Appendix A**) and Section 3.6.6, and then placed into the appropriate sample cooler (if required) for transport to the laboratory. Custody of the sample will be maintained according to the *Chain-of-Custody* SOP, included in **Appendix A**.
- When a field duplicate sample is required (1 for every 10 field samples collected), the sample will be evenly split following mixing of the material and removal of extraneous material, and each aliquot placed into an appropriately labeled sample container.
- If insufficient soil for sampling is obtained from the original borehole, then an adjacent location will be considered.

3.6.5 Former Building Sites/Areas Soil Survey Unit Investigation

Former building site soil SUs will be characterized in a similar fashion as the RSY process described in Section 3.6.3, using a combination of surface soil gamma scan surveys and systematic and biased soil sampling. The ROCs for the former building sites are listed in **Table 3-8**.

Gamma scan surveys will be performed using one or a combination of the gamma detectors listed in **Table 3-6**. The scan surveys will be performed using the same protocols and methods as those in the RSY pads. One hundred percent of the accessible surface of the former building site soil SUs will be gamma scan-surveyed using the Eagle iScan^{SM} overland or handheld systems, equipped with a gamma scintillator, real-time gamma spectroscopy and data logging.

If GPS reception is available, then gamma scan surveys will be position-correlated with GPS data. If GPS reception is not available, then a reference coordinate system will be established to document gamma scan measurement locations. The reference coordinate system will consist of a grid of intersecting lines referenced to a fixed site location or benchmark. If practical, the GPS coordinates of the fixed location or benchmark will be recorded.

The data collected during the gamma scan using the Eagle iScan^{SM} are evaluated as described in Section 3.5.1.1. Data sets will be transferred from the data logger onto a personal computer to create spreadsheets and, if feasible, gamma scan survey results will be mapped. Data obtained during the surface gamma scan surveys, including gross gamma, and individual radionuclide spectral measurements, will be analyzed to identify areas where surface radiation levels appear to be greater than the radionuclide-specific ILs using ROI-peak identification tools.

If gamma scan surveys indicate areas of potentially elevated activity in soil above the ILs (Section 3.3.1), then an investigation of the potential area of elevated activity will be initiated. At a minimum, the gamma scan data and collection of biased soil samples will be conducted. The biased soil sample will be collected from the approximate location of the highest elevated gamma scan survey measurement. If areas displaying elevated activity are collocated, then an attempt will be made to locate the area with the highest gamma scan results and designate it as the biased sample location to represent the collocated elevated areas. Potentially elevated material will remain segregated until completion of the investigation activities.

Areas known or suspected of containing radioactive materials or radioactive objects will be isolated and marked with immediate notification to the Navy.

3.6.5.1 Surface Soil Sample Collection

Prior to surface soil sampling, the necessary gamma scan measurements will be collected as described above. The location of the 14 systematic soil samples will be determined using VSP software, or equivalent, and located using GPS if available, or the established reference coordinate system used during the gamma scan survey. The systematic and biased soil samples collected from each SU will be collected based on the process described in Section 3.6.5.1 and submitted to the offsite analytical laboratory for analysis according to the SAP (**Appendix A**).

Surface soil samples will be collected in accordance with the *Soil Sampling* SOP, included in **Appendix A**. Disposable sampling equipment will be used whenever practical and will be disposed of immediately after use. If reusable sampling equipment is used, then decontamination between sampling locations will be performed following the RP 120 *Personnel Survey and Decontamination* SOP, included in **Appendix C**. Generally, the surface soil sample will be collected as follows:

- A clean shovel, hand auger, or other tool will be used to remove a small area (about 3 inches in diameter) of soil to a depth of 6 inches.
- The removed soil will be transferred directly into a clean stainless-steel bowl for mixing.
- The sample for radiological analyses will be mixed in the field by breaking the sample into small pieces, removing overburden gravel and biological material. The entire mixed sample, or aliquot thereof, will be placed in the designated laboratory sample container.
- When a field duplicate sample is required (1 for every 10 field samples collected), the duplicate sample will be collected following mixing of the material and splitting the aliquot into an additional sample container.
- Samples will be identified, labeled, and cataloged according to the SAP (**Appendix A**) and Section 3.6.6, and then placed into the appropriate sample cooler (if required) for transport to the contract laboratory. Custody of the sample will be maintained according to *Chain-of-Custody* SOP, included in **Appendix A**.

- A minimum of 200 grams of soil (approximately 1 cup) are required to complete all required analyses, or 400 grams if the sample is selected as a field duplicate.

3.6.6 Sample Identification

Each soil sample will be uniquely identified at the time of collection as described herein.

3.6.6.1 Phase 1 Trench Unit Samples

Sample identifications (IDs) from the Phase 1 soil trench unit investigation will use the following format:

HPPE-CCC-NNNA-DDD

Where: HP = Hunters Point
PE = Parcel E
CCC = excavation soil unit (ESU) or sidewall and floor unit (SFU)
NNN = former trench unit number
A = alpha-numeric digit of each "batch" (beginning with A), in sequential order
DDD = numeric sample digit (beginning with 001), in sequential order

For example, the first soil sample collected from the third "batch" of backfill TU material excavated from the former TU-152 will be identified as follows:

HPPE-ESU-152C-001

In this example, "ESU" identifies excavation soil unit, "152" identifies the unit as being excavated from the former Trench Unit 152 (TU-152), "C" represents the third unit or "batch" created from excavating this former TU, and "001" identifies the first sample.

3.6.6.2 Phase 2 Trench Unit Samples

Sample IDs from the Phase 2 soil trench unit investigation will use the following format:

HPPE-CCC-NNN-EEFF-GG-DDD

Where: HP = Hunters Point
PE = Parcel E
CCC = excavation soil unit (ESU) or sidewall and floor unit (SFU)
NNN = former trench unit number
EEFF = two-digit sample interval in feet bgs (EE = top of sample interval and FF = bottom of sample interval). EE and FF are whole numbers such that a value of "01"represents "1 foot bgs." Surface samples (samples collected from the 0.0- to 0.5-foot depth interval) will be designated as 000H (H is for half foot). If the surface sample is collected from a depth other than a half foot, then the H designation will still be used; however, a note will be included in the field book to indicate the actual depth sampled.
GG = soil boring number within the TU
DDD = numeric sample digit (beginning with 001), in sequential order

For example, the first soil sample collected from the ground surface of sidewall TU material from the former TU-201 will be identified as follows:

HPPE-SFU-201-000H-01-001

In this example, “SFU” identifies sidewall floor unit, “201” identifies the unit as being excavated from the former Trench Unit 201 (TU-201), “000H” represents the depth interval for a surface sample (000H is the agreed-upon code established for surface samples as explained above), “01” identifies soil boring number 01, and “001” identifies the first sample.

3.6.6.3 Former Building Sites/Areas Soil Survey Unit Samples

Sample IDs from the soil SU investigation will use the following format:

HPPE-CCCC-SUNN-DDD

Where: HP = Hunters Point
PE = Parcel E
CCCC = building site name
SUNN = survey unit number
DDD = numeric sample digit (beginning with 001, in sequential order)

For example, the second soil sample collected from Survey Unit 4 at the former Building 503 site will be identified as follows:

HPPE-0503-SU04-002

In this example, “503” identifies former Building 503, “SU04” identifies the unit as being Survey Unit 4 (SU-04), and “002” identifies the second sample.

3.6.7 Site Restoration and Demobilization

The open excavations will be backfilled with the excavated soil upon concurrence from the Navy. The excavated material will be returned to the same trench that the material originated from. If additional backfill is required, then a clean import source will be identified and used. Imported fill will be sampled and analyzed in accordance with the Basewide Radiological Management Plan (TtEC, 2012) and will be approved by the Navy before use. If the trench excavations are impacted by either groundwater or stormwater, then crushed rock or gravel will be placed as bridging material. With Navy concurrence, radiologically cleared recycled fill materials (e.g., crushed asphalt) may be used for backfill. The backfill will be compacted to 90 % relative density by test method ASTM D1557. Once an excavated area has been backfilled, the area will be restored to pre-removal action conditions.

3.6.7.1 Deconstruction of Radiological Screening Yard Pads

Following completion of radiological screening and upon direction from the Navy, the RSY pads will be deconstructed. Before deconstruction, the RSY pads will be radiologically screened and released in accordance with Section 6 of this RSEWP. The area will be down posted for the deconstruction activities. The RSY pad material will be consolidated on site for either reuse on site or off-site disposal at an approved disposal facility (Section 7). Following deconstruction, the area will be restored to pre-removal action conditions.

3.6.7.2 Decontamination and Release of Equipment and Tools

Decontamination of materials and equipment will be conducted as required at the completion of fieldwork. Decontamination follows the performance of alpha/beta contamination surveys and gamma scan/static measurements. Numerous decontamination methods are available for use. If practical, manual decontamination methods will be used. Abrasive methods may be necessary if areas of fixed contamination are identified. Chemical decontamination can also be accomplished by using detergents for nonporous surfaces with contamination present. Chemicals will be selected for decontamination that will minimize the creation of mixed waste. Decontamination activities will be conducted using SOP RP-132, *Radiological Protective Clothing Selection, Monitoring, and Decontamination* (**Appendix C**).

Visible dirt or debris will be removed from equipment with a brush and/or a masslinn wipe. The equipment and wipe will be measured to confirm the absence of activity above applicable control levels (AMS-710-07-WI-40111, "Performing and Documenting Radiation and Contamination Surveys" [APTIM, 2020]) and using the surface contamination criteria from Radiation Safety Surveys at Medical Institutions, Regulatory Guide 8.23 (NRC, 1981). In RCAs, equipment decontamination and release will be in accordance with the RPP (APTIM, 2019b), and project specific work instructions. Detectable levels of activity during decontamination will trigger notification to the Navy for further direction.

For larger pieces of equipment, equipment decontamination areas will be constructed by placing an impermeable surface (e.g., plastic sheeting) to catch material removed from equipment. At a minimum, equipment will be decontaminated by dry brushing.

3.6.8 Demobilization

Demobilization will consist of surveying, decontaminating, and removing equipment and materials; cleaning the project site; inspecting the site; and removing temporary facilities. Survey of equipment and materials will be performed in accordance with Section 6.6, and decontamination will be performed in accordance with Section 3.6.7.2. Demobilization activities will also involve collection and disposal of contaminated materials, including decontamination water and disposable equipment for which decontamination is inappropriate (Section 7).

3.7 Radiological Laboratory Analysis

Samples will be containerized and submitted to offsite laboratory with appropriate chain-of-custody documentation as established in the SAP (**Appendix A**). All laboratory analyses will be performed by a laboratory accredited by the Department of Defense Environmental Laboratory Accreditation Program or the National Voluntary Laboratory Accreditation Program and certified by the State of California to perform analyses. All soil samples will be retained for possible CDPH confirmatory analysis until the final RACR for Parcel E is issued.

Analysis will be based on the site-specific ROCs listed in **Table 3-4**, and in accordance with the SAP (**Appendix A**) and as follows:

- For Phase 1 and Phase 2 TU soil sampling, each soil sample will be assayed using gamma spectroscopy analysis for ^{137}Cs and ^{226}Ra. Gamma spectroscopy data will be reported for the gamma-emitting ROCs by the laboratory after a 7-day ingrowth period, providing a preliminary result for ^{226}Ra and a final result for ^{137}Cs, and again after a full 21-day ingrowth period, providing a final result for ^{226}Ra.

  - If the gamma spectroscopy laboratory results indicate a concentration of ^{226}Ra above the RG in a sample, then the sample will be analyzed using alpha spectroscopy for uranium isotopes (^{238}U, ^{235}U, and ^{234}U), thorium isotopes (^{232}Th, ^{230}Th, and ^{228}Th), and ^{226}Ra to evaluate equilibrium conditions. Additional details regarding the equilibrium evaluation are provided in Section 5.6. All detected isotopes will be reported.
  - If laboratory results indicate a concentration of ^{137}Cs above the RG in a sample, then the sample will be analyzed by gas flow proportional counting for ^{90}Sr and by alpha spectroscopy for ^{239}Pu
  - At least 10% of randomly selected TU soil samples will be analyzed by gas flow proportional counting for ^{90}Sr.
    - If laboratory results indicate a concentration of ^{90}Sr above the RG in a sample, then the sample will be analyzed via alpha spectroscopy for ^{239}Pu.
- At the Former Building Sites in Parcel E, each soil sample will be assayed using gamma spectroscopy analysis for ^{137}Cs, ^{226}Ra, and will be analyzed by gas flow proportional counting for ^{90}Sr.
- At the Former Buildings 506, 510/510A, 704, 707 Triangle, and 500 Series, where ^{239}Pu is an ROC, at least 10 % of randomly selected systematic soil samples will be analyzed by alpha spectroscopy for ^{239}Pu.
- At the Former Buildings 506 and 500 Series, where ^{241}Am is an ROC, at least 10 % of randomly selected systematic soil samples will be analyzed by gamma spectroscopy for ^{241}Am.
- At the Former Building 517, where ^{60}Co is an ROC, at least 10 % of randomly selected systematic soil samples will be analyzed by gamma spectroscopy for ^{60}Co.
- At the Former Buildings 506 and 529, where ^{3}H is an ROC, at least 10 % of randomly selected systematic soil samples will be analyzed by liquid scintillation for ^{3}H.
- At the Former 707 triangle area, where ^{235}U is an ROC, at least 10 % of randomly selected systematic soil samples will be analyzed by alpha spectroscopy for ^{235}U.

All laboratory data packages will have independent data verification and data validation performed to demonstrate that the data meet the project objectives. Following independent data verification and validation, the sample data will be evaluated as described in Section 5.

4.0 BUILDING INVESTIGATION DESIGN AND IMPLEMENTATION

This section describes the DQOs, ROCs, RGs, ILs, and radiological investigation design and implementation for Parcel E buildings.

4.1 Data Quality Objectives

The DQOs for the building investigation are as follows:

- **Step 1 - State the Problem**: Data manipulation and falsification were committed by a contractor during past building surveys. The Technical Team evaluated building data and found evidence of potential manipulation and falsification. The findings call into question the reliability of the data and issues regarding whether radiological contamination was present or remains in place are uncertain. Therefore, the property cannot be transferred as planned. Based on the uncertainty and the description of radiological activities in the HRA, residual radioactivity may potentially be present on building interior surfaces.
- **Step 2 - Identify the Objective:** The primary objective is to determine whether site conditions are compliant with the Parcel E ROD RAO (Navy, 2013).
- **Step 3 - Identify Inputs to the Objective:** The inputs include alpha-beta static, alpha and beta scan, and alpha-beta swipe data on building and reference area surfaces.
- **Step 4 - Define the Study Boundaries:** The study boundaries are accessible interior surfaces of Buildings 406, 414, 521, and 810 (**Figure 4-1**). The building floor plans with the Class 1 SUs depicted are presented on **Figure 4-2**, **Figure 4-3**, **Figure 4-4**, and **Figure 4-5**, respectively.
- **Step 5 - Develop Decision Rules:**
  - If the investigation results demonstrate that there are no exceedances determined from a point-by-point comparison with the statistically based RGs at agreed upon statistical confidence levels, or that residual ROC concentrations are NORM or anthropogenic background, then a RACR will be developed. The RACR will describe the investigation activities, present the results of the investigation, compare the distribution of data from the sites with applicable reference area data, and provide a demonstration that site conditions are compliant with the Parcel E ROD RAO through the use of multiple lines of evidence including application of statistical testing with agreed upon statistical confidence levels on the background data.
  - If the investigation results demonstrate exceedances of the RGs determined from a point-by-point comparison with the statistically-based RGs at agreed upon statistical confidence levels and are not shown to be NORM or anthropogenic background, then a RSER will be developed in place of the RACR. The RSER will include recommendations for further action based on EPA's most recent guidance *Radiation Risk Assessment at CERCLA Sites: Q&A* (USEPA, 2014).
- **Step 6 - Specify the Performance Criteria:** The data evaluation process for demonstrating compliance with the Parcel E ROD RAO is presented in Section 5, depicted on **Figure 4-6**, and summarized as follows:

- Compare each net alpha and net beta result to the corresponding RG presented in Section 4.3. If all results are less than or equal to the RGs, then compliance with the Parcel E ROD RAO is achieved.
- Compare survey data to appropriate RBA data from HPNS as described in Section 5. Multiple lines of evidence will be evaluated to determine whether site conditions are consistent with NORM or anthropogenic background. The data evaluation may include, but is not limited to, population-to-population comparisons, use of an MLE or BTV, and graphical comparisons. If survey data are consistent with NORM or anthropogenic background, then site conditions comply with the Parcel E ROD RAO.
- If any result is greater than the RG and cannot be attributed to NORM or anthropogenic background, then a Removal Site Evaluation Report will be developed in place of the RACR.

- **Step 7 - Develop the Plan for Obtaining Data:** Radiological investigations will be conducted on floors, wall surfaces, and ceiling surfaces, and will consist of alpha and beta scan surveys, alpha-beta static measurements, and alpha-beta swipe samples as described herein.

4.2 Radionuclides of Concern

The ROCs for Parcel E buildings, as identified in the HRA, include ^{137}Cs, ^{239}Pu, ^{226}Ra, and ^{90}Sr and are presented in **Table 4-1**.

4.3 Remediation Goals

The building data from the radiological investigations will be evaluated to determine whether site conditions are compliant with the RAO in the Parcel E ROD (Navy, 2013). The RAO is to prevent exposure to ROCs in concentrations that exceed RGs for all potentially complete exposure pathways. These RGs for structures, equipment, and waste are presented in **Table 4-2** as both total (fixed and removable) and removable surface radioactivity for each of the ROCs identified for the applicable buildings. Also identified for each ROC is the primary particle type emitted during the ROC's decay or during the ROC's radioactive progeny's decay.

Data collected from building surfaces during this investigation represent the total (fixed and removable) and removable gross activity on the surface, which may result from radiations from multiple radionuclides. Because these survey data are radiation-specific (α and β) but not radionuclide-specific, they cannot be attributed to a particular ROC. Instead, the survey data will be compared to the most restrictive building-specific RG_α and RG_β as presented in **Table 4-3**. For each building, the RG_α is chosen as the structure's lowest RG for an alpha-emitting ROC, and the RG_β is chosen as the structure's lowest RG for a beta-emitting ROC.

4.4 Radiological Investigation Design

This section describes the design of radiological investigations, including scan and static measurements on building surfaces. The radiological investigation design is based on methods, techniques, and instrument systems in the Basewide Radiological Management Plan (TtEC, 2012), with the ultimate requirement to demonstrate compliance with the Parcel E ROD RAO.

The principal features of the investigation protocol to be applied to the Parcel E building SUs are discussed herein and include the following:

- Determine the SUs.
- Select survey instruments.
- Determine instrument ILs and MDCs.

To the extent possible, manual data entries will be eliminated by using electronic data collection and transfer processes.

4.4.1 Building Survey Overview

The radiological surveys of the Parcel E buildings have two primary components (scanning measurements and static measurements), which are discussed in subsections 4.4.1.1 and 4.4.1.2, respectively. In addition, swipe samples will be collected to assess potential gross alpha and beta removable contamination. If needed, swipe samples will be analyzed off site to speciate the radionuclides present. Building material samples may be collected and analyzed off site to characterize areas of interest identified by the surveys.

4.4.1.1 Scanning Measurements

Scanning measurements will be performed on building surfaces to locate radiation anomalies indicating residual radioactivity that may require further investigation or remediation. As noted in Section 4.3, the scanning design is dictated by the most restrictive RG_α and RG_β values for the building. Where appropriate, scanning measurements will be performed using the assumptions of equilibrium described in Section 4.5.5.

4.4.1.2 Static Measurements

Static measurements will be the primary means of demonstrating compliance. Gross alpha and beta static measurements will be performed so that the measurement MDC is below the most restrictive RG_α and RG_β values for the building.

Static measurements will be performed in each SU and in the RBAs. They will consist of measurements in scaler mode for simultaneous alpha-beta counting using a Ludlum Model 43-68 gas proportional detector, Ludlum Model 43-93 plastic scintillation detector, or other appropriate instrument. While 1-minute count times were used in the following example calculations, static count times will be updated during investigations to meet DQOs using instrument-specific information. Static measurements will be performed on a systematic sampling grid and biased to locations identified by the alpha-beta scanning surveys.

The number of systematic static measurements performed will be based on the guidance described in MARSSIM Section 5.5.2.2 (USEPA et al., 2000) using the unity rule as the example basis for calculating the minimum static measurement frequency. Even if the MARSSIM-recommended or other statistical tests are not used to evaluate site data, these calculations serve as a basis for determining the number of static measurements per SU to be performed. The number of biased static measurements will be determined based on results of scan surveys.

MARSSIM Section 5.5.2.2 defines the method for calculating the number of static measurements when residual radioactivity is uniformly present throughout an SU. Therefore, determining the number of static measurements will be based on the following factors:

- RG for radioactivity on structural surfaces (UBGR);
- LBGR;
- Estimate of variability (standard deviation [σ]) in the reference area and the SUs;
- Shift (Δ = UBGR-LBGR);
- Relative shift ([UBGR-LBGR]/σ), as determined by **Equation 4-1**; and
- Decision error rates for making a Type I or Type II decision error that the mean or median concentration exceeds the RG (determined via Table 5.2 of the MARSSIM).

Each of the preceding factors is addressed in the following paragraphs. Example data are provided to assist in explaining the process for calculating the minimum static measurement frequency. Actual numbers of static measurements for SUs will be based on reference area data once they become available. When using the unity rule, the RG is defined as 1 (unitless) plus background. As a basis for the calculations, the background surface activity concentration is assumed to be 0.5.

MARSSIM defines a gray region as the range of values in which the consequences of decision error on whether the residual surface activity is less than or exceeds the RG are relatively minor. The RG of 1 above background (0.5) was selected to represent the UBGR (1.5). The LBGR is the median concentration in the SU, and the retrospective power will be determined after the survey is completed. If sufficient usable data is not available prior to performing the investigation activities, then Section 2.5.4 of the MARSSIM suggests arbitrarily selecting the LBGR as half the RG. Therefore, for this example, the LBGR = 0.5 x 1.5 = 0.75. Assuming the UBGR equals the RG, then Δ = 1.5 – 0.75 = 0.75 for this example.

MARSSIM defines σ as an estimate of the standard deviation of the measured values in the SU. Because SU data will not be available until the investigation activities are completed, MARSSIM recommends using the standard deviation of the RBA as an estimate of σ. Given the absence of data prior to performing the investigation activities, an arbitrary value of 0.25 has been selected as an estimate of σ for this example.

The relative shift is calculated based on MARSSIM guidance (Section 5.5.2.2) as shown in **Equation 4-1**.

Equation 4-1

$$\frac{\Delta}{\sigma} = \frac{(UBGR - LBGR)}{\sigma} = \frac{(RG - LBGR)}{\sigma} = \frac{(1.5 - 0.75)}{0.25} = 3.0$$

The minimum number of samples assumes the ROC concentration in the SU exceeds the RG. Type I decision error is deciding that the ROC concentration in the SU is less than the RG when it actually exceeds the RG. To minimize the potential for releasing buildings with concentrations above the RG, the Type I decision error rate is set at 0.01. Type II decision error is deciding that the ROC concentration exceeds the RG when it is actually less than the RG. To protect against remediating building surfaces with concentrations below the RG, the Type II decision error rate is set at 0.05, as recommended by MARSSIM.

MARSSIM Table 5.3 lists the minimum number of static measurements to be performed in each SU and RBA based on the relative shift and decision error rates. For a relative shift of 3, a Type I decision error rate at 0.01, and Type II decision error rate of 0.05, MARSSIM Table 5.3 recommends a minimum of 14 static measurements in each SU and RBA.

Initially, a minimum of 14 static measurements will be collected as a placeholder until background data are available. The minimum number of static measurements per SU will be developed based on the variability observed in the RBA data. The DQA of SU data will include a retrospective power curve (based on the MARSSIM Appendix I guidance) to demonstrate that enough static measurements were collected to meet the project objectives. If necessary, additional static measurements may be collected to comply with the project objectives.

4.4.2 Radiological Background

Building 404 will be used as the primary RBA in the investigation of Parcel E buildings. The location of Building 404 is shown on **Figure 4-1**. Building 404 is a non-impacted, unoccupied, former supply storehouse constructed in 1943 (see Reference 1598 in NAVSEA, 2004). From the same construction era and with materials similar to those of the impacted buildings in Parcel E, Building 404 has 43,695 square feet of concrete floors, a wooden superstructure, prepared roll or composition roof, and drywall offices.

At least 14 static and swipe measurements will be taken on each surface material type (e.g. concrete, wood, drywall, etc.) in the RBA that is representative of the material in the building SUs. Alternate RBAs may be identified and used if needed based on site-specific conditions identified during the building investigations.

4.4.3 Survey Units

Each Parcel E building will be divided into identifiable SUs similar in area and nomenclature to the previous investigation of each building. **Table 4-4** lists the SUs, classification, and areas by building. Generally, impacted floor surfaces and the lower 2 meters of remaining impacted wall surfaces will form Class 1 SUs of no more than 100 m^2 each. The remaining impacted upper wall surfaces (greater than 2 meters above the respective floor) and ceilings will generally form Class 2 SUs of no more than 2,000 m^2 each.

Several buildings on HPNS were remediated for lead and asbestos. This resulted in most of the interior wall and ceiling surfaces being removed, leaving only the wall structural components (i.e., wooden or metal framing). Areas with known releases have been remediated and recovered during past investigations such that no areas of suspected surface or volumetric contamination remain in Parcel E buildings. This investigation measures only the remaining, accessible and impacted surfaces through a combination of scanning, static, and swipe measurements. The SU designations and floor boundaries will remain the same as those used in the historical TtEC investigations;

however, the overall survey area will be reduced by the amount of area remediated for lead-based paint and asbestos.

The floor plans and floor SUs are shown for each building on **Figure 4-2** through **Figure 4-5**. **Figure 4-7** and **Figure 4-8** depict SU-specific details for a Class 1 SU and a Class 2 SU, respectively. **Figure 4-7** is a two-dimensional representation of SU-01 at Building 521 and shows the Class 1 floors, remaining lower wall surfaces, and intended static measurement and swipe sample locations. **Figure 4-8** is a two-dimensional representation of SU-04 at Building 521 and shows the Class 2 upper walls, ceiling, and intended static measurement and swipe sample locations.

Additional building-specific information regarding the Parcel E buildings is provided in the following paragraphs and in **Table 4-4**.

4.4.3.1 Building 406

Building 406 includes 42 Class 1 SUs (SUs 1 to 42) consisting of concrete and asphalt flooring and perimeter concrete perimeter lower walls. The Class 1 SU boundaries are shown on **Figure 4-2**. Building 406 also includes one Class 2 SU (SU 43), consisting of all the concrete perimeter upper walls and the ceiling.

The limiting alpha-emitting ROC for Building 406 is ^{226}Ra and the limiting beta-emitting ROC is ^{137}Cs.

4.4.3.2 Building 414

Building 414 includes 19 Class 1 SUs (SUs 1 to 19) consisting of mixed soil/gravel floors (SUs 1 to 13), and perimeter concrete lower walls (SUs 14 to 19). The Class 1 SU boundaries are shown on **Figure 4-3**. The survey methods in SUs 1-13 will consist of fixed static (direct) and scan measurements for gamma radiation, along with the collection of soil samples (described in Section 4.6.3.6). Building 414 also includes one Class 2 SU (SU 20), formed by the first-floor concrete ceiling and perimeter concrete upper walls.

The limiting alpha-emitting ROC for Building 414 is ^{226}Ra. No beta-emitting ROCs have been identified for Building 414.

4.4.3.3 Building 521

Building 521 includes 6 Class 1 SUs (SUs 1, 2, 3, 5, 6, and 7) consisting of concrete flooring and perimeter sheet metal or interior sheetrock lower walls. The Class 1 SU boundaries are shown on **Figure 4-4**. Building 521 also includes one Class 2 SU (SU 4), which includes the upper wall areas from 2 to 4 meters above the floor, and one Class 3 SU (SU 8), which includes the roof.

The limiting alpha-emitting ROC for Building 521 is ^{226}Ra and the limiting beta-emitting ROC is ^{90}Sr.

4.4.3.4 Building 810

Building 810 includes 28 Class 1 SUs (SUs 1 to 28) covering the floors and walls less than or equal to 2 meters above the respective floor areas (**Figure 4-5**). Building 810 also includes one Class 2 SU (SU 29) for the area 2 to 4 meters above the respective floor surfaces.

The limiting alpha-emitting ROC for Building 810 is ^{226}Ra and the limiting beta-emitting ROC is ^{90}Sr.

4.4.4 Reference Coordinate System

Survey unit scan lanes and static measurement locations will be marked using a consistent reference coordinate system throughout the building. In the absence of other technologies, locations will reference from the southernmost and westernmost points in the SU.

4.5 Instrumentation

Investigation data will be collected using position-correlated plastic scintillation detectors, gas proportional detectors, scintillation detectors, and swipe sample counters as described herein.

4.5.1 Position-correlated Scintillation Detectors

Large area surface scanning and static measurements for alpha and beta radiations will be performed using the Environmental Restoration Group (ERG) Model 102F Floor Scanning System which is a position-correlated dual layer scintillation detector (or equivalent system).

The ERG 102F uses off-the-shelf Ludlum equipment for radiological detection. The system uses the 6-zone Ludlum 43-134-4 zinc-sulfide plastic scintillator detector and Ludlum Model 4612 counter modified for dual-channel alpha/beta counting. The system also employs a stepper motor to maintain a user-set survey scan speed of the cart. The ERG Model 102F consists of a roll-around cart containing all the necessary equipment and software to acquire position-correlated radiological scan data from floor surfaces and export the data for processing using a variety of applications, such as Microsoft Excel, ESRI ArcGIS, or the ERG Data Manager Software.

4.5.2 Gas Proportional Detectors

Gas proportional detectors, such as the large area Ludlum Model 43-37, small area Ludlum Model 43-68, or equivalent instruments, will be used for scanning measurements in areas that are not accessible to or practicable for the ERG Model 102F. The Ludlum Model 43-37 detector is 2.5 cm high by 15.9 cm wide by 46.4 cm long, with an active area of 584 cm^2. The Ludlum Model 43-68 is 10 cm high by 11.7 cm wide by 19.8 cm long, with an active area of 126 cm^2. Scanning speed is controlled by the surveyor and data are automatically logged when used with an appropriate data-logging scaler/ratemeter, such as the Ludlum Model 2360 or equivalent. The Ludlum Model 43-68 may also be used to perform static measurements.

4.5.3 Scintillation Detectors

Alpha-beta scintillation detectors may also be used for scanning and static measurements. The Ludlum Model 43-93 has an active detector area of 100 cm^2 and simultaneously counts alpha radiation using a zinc sulfide scintillator and beta radiation using a thin plastic scintillator.

4.5.4 Alpha-Beta Sample Counter

Swipe samples to assess removable activity will be performed using an alpha-beta plastic scintillation counter, such as the Ludlum Model 3030 Alpha-Beta Sample Counter, or equivalent. The Ludlum Model 3030 has an active detector area of 20.3 cm^2 and simultaneously counts alpha-beta radiation from 5.1 cm swipe papers loaded into a single sample tray.

4.5.5 Instrument Efficiencies

Manufacturer-provided parameters are provided in **Table 4-5**, including the detector physical (active) areas, detector widths in the direction of scanning, total (4π) efficiencies, and background count rates. Instrument-specific efficiencies (from calibration certificates) and background count rates will be used during the investigation to complete the instrument-specific calculations. In accordance with NUREG-1507 (NRC, 1998), during survey activities total 4-π efficiencies for alpha/beta instruments will be determined by multiplying the reported 2-π instrument efficiency (ε_i) from the instrument calibration and a source efficiency (ε_s) of 0.5 for beta emitters with maximum beta energies exceeding 0.4 MeV, and 0.25 for beta emitters with maximum beta energies between 0.15 and 0.4 MeV and for alpha emitters. In the following sections, manufacturer-provided 4-π efficiencies are used to illustrate the example calculations.

The response of a detector to the incident radiations from building surfaces differs from the values in **Table 4-5** depending on the presence and state of equilibrium of radioactive progenies. Of the ROCs in **Table 4-1**, ^{226}Ra and ^{90}Sr have radioactive progenies that emit alpha or beta particles during their decay. The concentration of each progeny relative to its parent depends on its parent's decay fraction and the equilibrium fraction of the entire series or chain. The progeny isotope of ^{226}Ra is ^{222}Rn. Because radon (^{222}Rn) is a gas, a fraction of its concentration may escape the building area before decaying, and the relative abundance (equilibrium fraction) of the subsequent progenies is reduced. For the ^{226}Ra decay series, the radon decay products typically have a 0.4 equilibrium fraction indoors (see Question 17 in USEPA, 2014) such that the progeny of ^{222}Rn is only present at 40 % of the ^{222}Rn concentration.

In **Table 4-6**, each ROC and its progeny is listed along with the associated type of particle emitted during decay, the fraction of times that particle type is emitted, the radon decay product abundance relative to ^{222}Rn, and the 4-π efficiencies and 4-π weighted efficiencies for the three example detector types for building investigations. The 4-π weighted efficiencies for each radionuclide and detector is the product of its decay fraction, equilibrium fraction, and 4-π efficiency. The total alpha (or beta) 4-π weighted efficiencies for ^{226}Ra and ^{90}Sr are the summed alpha (or beta) 4-π weighted efficiencies of themselves and their progeny. To illustrate, the alpha response (4-π efficiency) of the ERG Model 102F to pure ^{226}Ra is 0.13 (or 13 counts per 100 disintegrations of ^{226}Ra). However, ^{226}Ra exists in partial equilibrium with its radioactive progeny, and for each disintegration of ^{226}Ra, there are 3.2 alpha particles and 1.6 beta particles formed. The resultant total alpha 4-π weighted efficiency for the ERG Model 102F and the ^{226}Ra chain is $0.13 \times 3.2 = 0.416$. Consistent with Section 4.3.2 of the MARSSIM (USEPA et al., 2000), the weighted efficiencies provided in **Table 4-6** are used for the instrument sensitivity calculations described in the remainder of this section.

4.5.6 Calibration

Portable survey instruments will be calibrated annually at a minimum, in accordance with ANSI N323 (ANSI, 1997), or an applicable later version. Instruments will be removed from service on or before calibration due dates for recalibration. If ANSI N323 does not provide a standard method, then the calibration facility should comply with the manufacturer's recommended method.

4.5.7 Daily Performance Checks

Before using the portable survey instruments, calibration verification, physical inspection, battery check, and source-response check will be performed in accordance with SOP RP-108, *Count Rate Instruments,* and SOP RP-109, *Dose Rate Instruments* (**Appendix C**). Portable survey instruments will have a current calibration label that will be verified daily before use.

Physical inspection of the portable survey instrument will include the following:

- General physical condition of the instrument and detector before each use;
- Knobs, buttons, cables, connectors;
- Meter movements and displays;
- Instrument cases;
- Probe and probe windows; and
- Other physical properties that may affect the proper operation of the instrument or detector.

Any portable survey instrument or detector having a questionable physical condition will not be used until problems have been corrected. A battery check will be performed to ensure that sufficient voltage is being supplied to the detector and instrument circuitry for proper operation. This check will be performed in accordance with the instrument's operations manual. The instrument will be exposed to the appropriate (alpha or beta) check source, to verify that the instrument response is within the plus or minus 20 % range determined during the initial response check. The calibration certificates and daily QA/QC records for each instrument used and the instrument setup test records will be provided in the project report.

If any portable survey instrument, or instrument and detector combination, having a questionable physical condition that cannot be corrected fails any of the operation checks stated in SOP RP-108, *Count Rate Instruments*, or SOP RP-109, *Dose Rate Instruments* (**Appendix C**), or has exceeded its annual calibration date without PRSO approval, the instrument will be put in an "out of service" condition. This is done by placing an "out of service" tag or equivalent on the instrument and securing the instrument or the instrument and detector combination in a separate area such that the instrument and instrument and detector combination cannot be issued for use. The PRSO and RPTs and their respective supervisors will be notified immediately when any survey instrumentation has been placed "out of service." Instruments tagged as "out of service" will not be returned to service until all deficiencies have been corrected. The results of the daily operation checks, discussed above, will be documented.

4.5.8 Instrument Detection Calculations and Investigation Levels

Instrument-specific parameters used for building investigations are calculated in the following sections. These include the average scan rate, ILs, alpha detection probabilities and MDCs for scanning measurements and the ILs and MDCs for static measurements. These calculations will be updated during building investigations (Section 4.6.3) using information from calibration sheets and background measurements for each instrument.

4.5.8.1 Scan Rate

While scanning, the amount of time that a moving detector spends above an area of elevated activity, or the dwell time (in seconds), depends on the rate of scanning (cm/s) and the size of the area of elevated activity (cm^2). The detector dwell time (t) is also called the detector residence time or observation interval (i) in some references. The size of any area of elevated activity cannot be known before investigation, so the conventional approach is to assume a typical size for the area (e.g., 100 cm^2) and choose a scan rate that provides a reasonable value for t. Generally, dwell times between 0.5 second and 2 seconds are considered reasonable. If the 100 cm^2 area of elevated activity is 10 cm x 10 cm, then these dwell times would result in average detector scan rate (v) between 5 and 20 cm/s.

Average scan rates for each instrument used for scanning will be determined during instrument preparations (Section 4.6.3.1) to meet required detection sensitivities. Movement of the ERG Model 102F is motor-controlled and has a fixed scan rate, v, which is typically between 1 and 15 cm/s. Movement of other large area detectors, such as the Ludlum Model 43-37, is controlled by the surveyor; the average scan rate will be monitored during scanning and verified during data evaluation.

4.5.8.2 Scan Investigation Levels

Scan data are compared to scan ILs. ILs are instrument-specific, ROC-specific, and surface material-specific surface activity levels, in units of the instrument's response (cpm). Scan data that exceed an applicable scan IL will be investigated using biased measurements (Section 4.6.3.4). Scan ILs will be updated during instrument preparations (Section 4.6.3.1).

The measurements for alpha and beta surface activity occur simultaneously during scanning; however, the signal detection theory for alpha emitters differs greatly from that of beta emitters. Surface conditions and other factors result in relatively low probabilities that alpha particles emitted from sources on a surface will reach the detector, while beta scanning provides a more reliable and efficient method for the detection of beta emitters. Given that ^{226}Ra has progeny that emit beta particles, the collection of beta scanning measurements will supplement and verify alpha scans where ^{226}Ra is an ROC.

Scan ILs are calculated using **Equation 4-2** and the detector-specific information in **Table 4-5** and **Table 4-6**. To enable direct comparison to the alpha ratemeter output during scanning, the RG for each alpha-emitting ROC is converted from units of dpm/100 cm^2 to cpm (beta) using **Equation 4-2**, which is based on the discussion of data conversion in Section 6.6.1 of the MARSSIM (USEPA et al., 2000). The beta scan IL is determined in a similar manner.

Equation 4-2

$$\text{Scan IL}_{(\alpha\text{ or }\beta)}\text{ (cpm)} = (RG_{(\alpha\text{ or }\beta)})(\varepsilon_{T\,(\alpha\text{ or }\beta)})\left({}^{A}\!/_{100\ cm^2}\right) + (R_{B\,(\alpha\text{ or }\beta)})$$

Where: $RG_{(\alpha\text{ or }\beta)}$ = remediation goal for alpha-emitting or beta-emitting ROC (dpm/100 cm^2)
$\varepsilon_{T(\alpha\text{ or }\beta)}$ = detector total (4-π) efficiency (counts per disintegration), equal to 2-π instrument efficiency (ε_i) multiplied by surface efficiency (ε_s)
A = detector probe physical (active) area (cm^2)
$R_{B(\alpha\text{ or }\beta)}$ = alpha or beta background count rate (cpm)

The preliminary scan ILs are shown in **Table 4-7**. Site-specific scan ILs will be determined during instrument preparations (Section 4.6.3.1).

4.5.8.3 Probability of Alpha Detection for High-background Detectors

The measurements for alpha and beta surface activity occur simultaneously during scanning; however, the signal detection theory for alpha emitters differs greatly from that of beta emitters. For alpha scanning, one verifies that while scanning at rate v, there is a specified probability (typically 90%) that surface activity present at the RG_α will be detected.

Equation 4-3 (adapted from Equation 6-14 in MARSSIM [USEPA et al., 2000]) is used for detectors having higher background rates (i.e., 5 to 10 cpm) to determine the probability of recording at least two alpha counts, $P(n \geq 2)$, while passing over an area contaminated at the RG_α, during t. It is assumed that all the elevated activity is contained in a 100 cm^2 area and that the detector passes over the area in one or multiple scan passes.

The probability of detecting two or more counts due to a source at the RG_α is given by Equation 4-3 (Equation 6-14 from MARSSIM [USEPA et al., 2000]), as follows:

Equation 4-3

$$P(n \geq 2) = 1 - \left(1 + \frac{[(G)(E) + (B)]t}{60}\right)\left(e^{-[(G)(E)+(B)]t/60}\right)$$

Where: $P(n \geq 2)$ = probability of getting two or more counts during the time interval t(%)
t = time interval (seconds)
G = contamination activity (disintegrations per minute [dpm]) = equal to the RG_α
E = total efficiency (4-π), equal to 2-π instrument efficiency (ε_i) multiplied by surface efficiency (ε_s)
B = background count rate (cpm)

As an example, the probability of getting two or more counts using the Ludlum Model 43-37 is calculated.

Typical alpha background values observed with the Ludlum Model 43-37 is 10 cpm. The total detector efficiency (4-π) of the Ludlum Model 43-37 for the alpha emission from ^{239}Pu is assumed to be 0.175, according to **Table 4-6**. The detector width is 13.3 cm in the direction of travel.

Survey speed for alpha emitters is 2.5 cm/s, resulting in a dwell time of 5.3 seconds. Using these parameters, **Equation 4-3** is solved as follows:

$$P(n \geq 2) = 1 - \left(1 + \frac{[(100)(0.175) + (10)](5.3)}{60}\right)\left(e^{-[(100)(0.175)+(10)](5.3)/60}\right) = 70\ \%$$

Where: $P(n \geq 2)$ = probability of getting two or more counts during the time interval t
t = 5.3 seconds
G = 100 dpm
E = 0.175 (total weighted efficiency for ^{239}Pu alphas from **Table 4-6**)
B = 10 cpm

As calculated above, the probability of getting two or more counts during the observation interval of 5.3 seconds when surveying a 100-dpm hotspot is equal to 70 % at a scan speed of 2.5 cm/s. Alpha detection probabilities and associated scan speeds for large area detectors will be updated as needed during survey preparation (Section 4.6.3.1) to reflect instrument-specific, ROC-specific, and surface material-specific information.

4.5.8.4 Probability of Alpha Detection for Low-background Detectors

The alpha count rate on various surfaces will typically average less than 5 cpm with detectors such as the Ludlum Model 43-68 or ERG Model 102F. When using a low-background detector, scanning for alpha emitters differs because the expected background response of most alpha detectors is close to zero. A single count in the defined residence time will result in a second measurement of equal duration. One or more additional counts will require investigation with a static measurement as described in Section 4.6.3.4.

The probability of detecting given levels of alpha surface contamination for smaller detectors can be calculated by use of Poisson summation statistics. Given a known measurement interval and a surface contamination release limit, the probability of detecting a single count for the measurement interval to be used during this project is given by Equation 6-12 of MARSSIM (USEPA et al., 2000), shown as **Equation 4-4**:

Equation 4-4

$$P(n \geq 1) = 1 - e^{-[(G)(E)(d)]/60v}$$

Where: $P(n \geq 1)$ = probability of observing a single count
G = contamination activity = RG_{α}
E = total efficiency (4-π), equal to 2-π instrument efficiency (ε_i) multiplied by surface efficiency (ε_s)
d = width of detector in direction of scan (cm)
v = scan speed (cm/s)

As an example, **Equation 4-4** may be solved for the ERG Model 102F as follows:

$$P(n \geq 1) = 1 - e^{-[(100)(0.21)(10)]/(60)(2.5)} = 75\ \%$$

Where: $P(n \geq 1)$ = probability of observing a single count
G = 100 dpm
E = 0.21 (**Table 4-6**)
d = 10 cm
v = 2.5 cm/s

As calculated above, the probability of getting one or more counts during an ERG Model 102F scan moving at 2.5 cm/s when surveying a 100-dpm alpha hotspot is equal to 75%. Alpha detection probabilities and associated scan speeds for small area detectors will be updated as needed during survey preparation (Section 4.6.3.1) to reflect instrument-specific, ROC-specific, and surface material-specific information.

4.5.8.5 Beta Scan Minimum Detectable Concentration

The rate at which each detection instrument traverses across the surface being surveyed is necessarily detector-specific and radionuclide-specific and varies with accepted error rates, surveyor efficiency, and surface beta background. We assume that 95% true positive (α = 0.95) and 5% false positive (β = 0.95) rates are required, such that d' = 3.28 (from Table 6.5 of the MARSSIM). A value of 0.5 for p, the surveyor efficiency, is typical for surveyor-controlled detectors and 1.0 for motor-controlled detectors or detectors equipped with automatic data and position logging. The β scan MDC is calculated using **Equation 4-5** (adapted from MARSSIM, Equation 6-10 [USEPA et al., 2000]). Instruments will be selected for scanning to ensure that their beta scan MDC is less than or equal to the RG_β for the building from **Table 4-3**. **Equations 4-5** through **4-7** are derived as follows:

Equations 4-5

$$\beta\ scan\ MDC\ (\text{dpm}/100\ \text{cm}^2) = \frac{MDCR}{(\sqrt{p})(\varepsilon_{i,\beta})(\varepsilon_{s,\beta})\left(^{A}/_{100\ cm^2}\right)}$$

Where: $MDCR$ = minimum detectable count rate
p = surveyor efficiency
$\varepsilon_{i,\beta}$ = detector (2-π) beta efficiency (counts per disintegration)
$\varepsilon_{s,\beta}$ = surface (2-π) beta efficiency (counts per disintegration)
A = detector physical (active) area (cm^2)

Substituting $MDCR = 60 \cdot s_i/i$ (MARSSIM Equation 6-9), $t = i$, $s_i = d' \cdot (b_i)^{1/2}$ (MARSSIM Equation 6-8) and $\varepsilon_{T,\beta} = \varepsilon_{i,\beta}\, \varepsilon_{s,\beta}$ yields **Equation 4-6**:

Equation 4-6

$$\beta\ scan\ MDC\ (\text{dpm}/100\ \text{cm}^2) = \frac{(60)(s_i/t)}{(\sqrt{p})(\varepsilon_{T,\beta})\left(^{A}/_{100\ cm^2}\right)} = \frac{(60)(d')(\sqrt{b_i}/t)}{(\sqrt{p})(\varepsilon_{T,\beta})\left(^{A}/_{100\ cm^2}\right)}$$

Where: s_i = minimum detectable net source counts in t
d' = index of sensitivity (for error rates α and β)
b_i = background counts in t
$t = d/v$ = detector dwell time (seconds)
d = width of detector in direction of scan (cm)
v = average scan rate (cm/s)
$\varepsilon_{T,\beta}$ = detector total (4-π) beta efficiency (counts per disintegration)

Substituting $b_i = R_{B,\beta}$ (cpm)·t (seconds)/60 yields **Equation 4-7**:

Equation 4-7

$$\beta\ scan\ MDC\ (\text{dpm/100 cm}^2) = \frac{(d')\sqrt{R_{B,\beta}\ (t/60)}\ \left({}^{60}/_{t}\right)}{(\sqrt{p})(\varepsilon_{T,\beta})\left({}^{A}/_{100}\right)}$$

Where: $R_{B,\beta}$ = background beta count rate (cpm)

The beta scan MDCs for each scan survey instrument and ROC are presented in **Table 4-8** for various detector average scan rates.

***Example**: Beta Scan MDC Calculation for Ludlum 43-68.*

The β scan MDC is calculated for the Ludlum 43-68 scanning for beta emitters at 5 cm/s and using the parameters presented in **Table 4-5** and **Table 4-6**. The surveyor efficiency, p, is set to 0.5 as recommended by MARSSIM.

$$\beta\ \text{scan MDC (43-68, }^{137}\text{Cs)} = \frac{(3.28)\sqrt{300\ (4.0/60)}\ \left({}^{60}/_{4.0}\right)}{(\sqrt{0.5})\ (0.20)\ \left({}^{126}/_{100}\right)} = 1{,}235\ \text{dpm/100 cm}^2$$

Where: d' = 3.28 (for 95% true positive and 5% false positive)
$R_{B,\beta}$ = 300 cpm
$t = d/v$ = 20 cm /(5 cm/s) = 4 seconds
p = 0.5
$\varepsilon_{T,\beta}$ = 0.20 for beta emitters
A = 126 cm^2

Following the Beta Scan MDC example calculation, Scan MDCs are calculated for the ERG Model 102F and the Ludlum Model 43-37. **Table 4-8** demonstrates that at a scan rate for the ERG Model 102F of 5 cm/s, the beta scan MDCs for all ROCs are below the most restrictive RG_β (1,000 dpm/100 cm^2 for ^{90}Sr) for both survey instruments. Beta scan MDCs and associated scan speeds will be updated as needed during survey preparation (Section 4.6.3.1) to reflect instrument-specific, ROC-specific, and surface material-specific information.

4.5.8.6 Static Investigation Levels

Static measurement data are compared to static ILs. Static measurement data that exceed an

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applicable static IL will be investigated using biased measurements (Section 4.6.3.4).

The alpha and beta static ILs are determined using the static measurement count time in **Equation 4-8**, which is based on the discussion of data conversion in MARSSIM Section 6.6.1 (USEPA et al., 2000). Static ILs will be updated as needed during survey preparation (Section 4.6.3.1) using instrument-specific, ROC-specific and surface material-specific information.

Equation 4-8

$$\text{Static IL}_{(\alpha \text{ or } \beta)}\text{ (counts)} = \left[(RG_{(\alpha \text{ or } \beta)})(\varepsilon_{T(\alpha \text{ or } \beta)})\left({}^{A}/_{100\ cm^2}\right) + R_{B(\alpha \text{ or } \beta)}\right]\ [T_{S+B}]$$

Where: $RG_{(\alpha \text{ or } \beta)}$ = remediation goal for alpha- or beta-emitting ROC (dpm/100 cm^2)
$\varepsilon_{T(\alpha \text{ or } \beta)}$ = detector total (4-π) efficiency (counts per disintegration), equal to 2-π instrument efficiency (ε_i) multiplied by surface efficiency (ε_s)
A = detector probe physical (active) area (cm^2)
$R_{B(\alpha \text{ or } \beta)}$ = alpha or beta background count rate (cpm)
T_{S+B} = SU static counting time (minutes)

For illustration, the following example calculates the alpha static IL equivalent to the ^{239}Pu RG for the Ludlum Model 43-93, on concrete, using a 1-minute static count time.

Example*: Alpha static IL for the Ludlum Model 43-93*

$$\text{Static IL}_{\alpha}\text{ (Ludlum Model 43-93, }^{239}\text{Pu)} = \left[(100)(0.200)\left({}^{100}/_{100}\right) + 1\right][1] = 21\text{ counts}$$

Where: $RG_{^{239}\text{Pu-}\alpha}$ = 100 dpm/100 cm^2
$\varepsilon_{T,\alpha}$ = 0.200 (total efficiency for ^{239}Pu, **Table 4-6**)
A = 100 cm^2
$R_{B,\alpha}$ = 1 cpm
T_{S+B} = 1 minute

4.5.8.7 Alpha Static Minimum Detectable Concentration

Simultaneous static alpha-beta (paired) measurements are typically taken with alpha-beta detectors coupled to scaler and ratemeter data loggers, and operated in scaler mode for the counting time, T. The division of counting times between background counting time, T_B, and SU counting time, T_{S+B}, is optimized such that the static MDCs will be less than or equal to the RG_α for the building from **Table 4-3**. The static MDC is the a priori net activity concentration above the critical level that is expected to be detected 95 % of the time. When the count times for the background and SU measurements are different, the static MDC, for either alpha or beta activity, is calculated using **Equation 4-9** (adapted from Strom and Stansbury, 1992). Any areas of elevated activity are assumed to be 100 cm^2 in size. MDC calculations for static measurements will be updated during survey preparations (Section 4.6.3.1) using instrument-specific, ROC-specific, and surface material-specific information.

Equation 4-9

$$\text{Static MDC (dpm/100 cm}^2) = \frac{3 + (3.29)\sqrt{R_B(T_{S+B})[1 + (T_{S+B}/T_B)]}}{(\varepsilon_T)(^{A}/_{100})(T_{S+B})}$$

Where: R_B = background count rate (cpm)
T_{S+B} = SU counting time (minutes)
T_B = background counting time (minutes)
ε_T = detector total (4-π) efficiency (counts per disintegration), equal to 2-π instrument efficiency (ε_i) multiplied by surface efficiency (ε_s)
A = detector probe physical (active) area (cm^2)

Instruments will be selected for static measurements to ensure that their alpha static MDC is less than or equal to the RG$_\alpha$ for the building from **Table 4-3**.

***Example**: Alpha Static MDC Calculation for the Ludlum Model 43-93.*

The alpha static MDC is calculated for the Ludlum Model 43-93 using the parameters presented in **Table 4-5** and **Table 4-6**. Using **Equation 4-9**, the calculated alpha static MDC for ^{239}Pu is 48 dpm / 100 cm^2.

$$\alpha \text{ Static MDC } (43\text{-}93, {}^{239}\text{Pu}) = \frac{3 + (3.29)\sqrt{2(1)[1 + (1/1)]}}{(0.200)(^{100}/_{100})(1)} = 48 \text{ dpm/100 cm}^2$$

Where: $R_{B,\alpha}$ = 2 cpm
T_{S+B} = 1 minute
T_B = 1 minute
$\varepsilon_{T,\alpha}$ = 0.200
A = 100 cm^2

4.5.8.8 Beta Static Minimum Detectable Concentration

Beta static MDC calculations are also performed using **Equation 4-9** and information from **Table 4-5** and **Table 4-6**. Instruments will be selected for static measurements to ensure that their beta static MDC is less than or equal to the RG$_\beta$ for the building from **Table 4-3**. MDC calculations for static measurements will be updated during survey preparations (Section 4.6.3.1) using instrument-specific, ROC-specific, and surface material-specific information.

The alpha and beta static MDCs for each survey instrument and ROC are presented in **Table 4-9** for 1-minute measurements in the SUs and RBAs.

4.6 Radiological Investigation Implementation

Investigations will be generally implemented in the following order of activities: premobilization, mobilization, surveys, additional investigations, and demobilization.

4.6.1 Premobilization Activities

Before the start of survey activities, a walkthrough of Parcel E buildings will be completed to accomplish the following:

- Establish building access points and assess security requirements.
- Assess survey support needs such as power, lighting, ladders, or scaffolding.
- Verify the types of materials in each SU.
- Identify safety concerns and inaccessible or difficult-to-survey areas.
- Identify radiological protection and control requirements.
- Identify materials requiring removal or disposal, and areas requiring cleaning.
- Assess methods for marking survey scan lanes and static measurement locations.

Impacted areas that are deemed unsafe for access or surveys, if any, will be posted, secured, and annotated in reports.

4.6.1.1 Training Requirements

Any required non-site-specific training required for field personnel will be performed before mobilization to the extent practical. Training requirements are outlined in Section 6. Medical examinations, medical monitoring, and training will be conducted in accordance with the APP/SSHP and Section 6 requirements. In addition to health and safety-related training, other training may be required as necessary including but not limited to the following:

- Aerial Lift (for personnel working from aerial lifts)
- Fall Protection (for personnel working at heights greater than 5 feet)
- Equipment as required (e.g., forklift, skid-steer loader, backhoe, excavator)

4.6.1.2 Permitting and Notification

Before initiation of field activities for the radiological investigations, the contractor will notify the Navy RPM, ROICC, RASO, Caretaker Site Office, and HPNS security as to the nature of the anticipated work. Any required permits to conduct the fieldwork will be obtained before mobilization. The contractor will notify the CDPH at least 14 days before initiation of activities involving the Radioactive Material License.

4.6.1.3 Pre-construction Meeting

A pre-construction meeting will be held before mobilization of equipment and personnel. The purpose of the meeting will be to discuss project-specific topics, roles and responsibilities of project personnel, project schedule, health and safety concerns, and other topics that require discussions before field mobilization. Representatives of the following will attend the pre-construction meeting:

- Navy (RPM, RASO, ROICC, and others as applicable)
- Contractor (Project Manager, Site Construction Manager, Project QC Manager, PRSO, and SSHO)
- Subcontractors as appropriate

4.6.2 Mobilization Activities

Mobilization activities will include site preparation, movement of equipment and materials to the site, and orientation and training of field personnel. At least 2 weeks before mobilization, the appropriate Navy personnel, including the Navy RPM, ROICC, and Caretaker Site Office, will be notified regarding the planned schedule for mobilization and site remediation activities. Upon receipt of the appropriate records and authorizations, field personnel, temporary facilities, and required construction materials will be mobilized to the site. The temporary facilities will include restrooms, hand-washing stations, and one or more secure storage (Conex) boxes for short- and long-term storage of materials, if needed.

The applicable AHAs will be reviewed prior to starting work.

All equipment mobilized to the site will undergo baseline radioactivity surveys in accordance with Section 6. Surveys will include directs scans, static measurements, and wipe samples. Equipment that fails baseline surveying will not be removed from site immediately.

Loose, residual debris present in the buildings that may interfere with the performance of planned surveys will be removed for disposal and to prepare the buildings for cleaning. Cleaning will be sufficient to remove loose, surface material that may not be native to the building construction and may inhibit or damage survey instruments. Cleaning activities will be conducted consistent with the radiation protection procedures in Section 6.4. Dust control methods and air monitoring will be implemented, if warranted, as detailed in Section 8.5. Floors will be cleaned using ride-on floor scrubbers and vacuums. Walls and other surfaces will be cleaned as required during surveying. Wet areas will be dried using vacuums, blowers, or squeegees and may be delineated with spill containment booms if water infiltration is recurrent. Waste from debris removal and cleaning activities will be evaluated as described in Section 6.4 and Section 7.

4.6.3 Building Investigation and Remediation Activities

Once all site preparation activities previously described are completed, building investigation and remediation activities will commence in the following general sequence:

- Mark SUs.
- Prepare instruments.
- Perform alpha-beta scanning in SUs and RBA and conduct preliminary data review.
- Perform alpha-beta systematic static and swipe measurements in SUs and RBA and conduct preliminary data review.
- Perform alpha-beta biased static and swipe measurements in SUs and conduct preliminary data review.
- Delineate and remediate residual contamination, if present.
- Evaluate and report data as described in Section 5.

4.6.3.1 Survey Unit Preparation

SUs will be durably marked prior to measurement activities to indicate SU boundaries, number, scan lanes and directions, and systematic measurement locations. Scan lane widths will be approximately 10 % smaller than the detector's active width, in the direction of scanning, to ensure overlapping coverage.

Upon receipt of survey instruments for the building investigations and completion of performance checks, background measurements will be obtained in the RBAs for each instrument and on each surface material type (e.g., concrete, metal, wood, and sheet rock) that is also present in the SUs. The background measurements will consist of at least 14 static measurements on each surface to match the number performed in each SU. The mean instrument- and material-specific background count rate will be used to update the instrument detection calculations and static count times in Section 4.5.8.

4.6.3.2 Survey Unit and Reference Background Area Alpha-Beta Scanning

Survey units will be scanned to detect alpha and beta emitters using average scan rates that ensure an alpha probability of detection of approximately 90 % (Sections 4.5.8.3 and 4.5.8.4) where feasible and that the beta scan MDC (Section 4.5.8.5) is less than or equal to the RG_{β} for the building (Section 4.3). Scanning will cover a total area of each SU according to its classification. The total surface area of remaining, accessible impacted surfaces to be scanned will be 100 % in Class 1 SUs, 50% in Class 2 SUs, and up to 10 % in Class 3 SUs.

The scan rate for the ERG Model 102F is a fixed, motor-controlled scan rate. At least once every 10 SUs of scanning, the ERG Model 102F scan rate will be verified manually using the distance scanned and scan duration. The distance scanned is the linear distance, in centimeters, traveled by the detector during data acquisition. The scan duration is the total time, in seconds, of data acquisition. Dividing the distance scanned (cm) by the scan duration (seconds) gives an estimate of the average detector scan rate (cm/s) for that scanning period. Direct observation or review of the positional data from the ERG Model 102F will also serve to verify the detector scan speed was acceptable. The scan rates for other planned instruments (e.g., Ludlum Model 43-37 and Ludlum Model 43-68) are manually controlled by the surveyor and will be verified manually in each SU by direct observation and measurement of the time elapsed while scanning a known distance.

While using the ERG Model 102F, scanning may traverse multiple SUs at once for efficiency, but alpha-beta scan data will be assigned to, and analyzed for, individual SUs. Areas inaccessible to the ERG Model 102F will be scanned using one of the other radiological detectors listed in **Table 4-5** equipped with automatic data logging. A DQA of the alpha-beta scan data (Section 5.2) will identify locations that exceed the applicable beta scan IL (Section 4.5.8.2) and, therefore, require further investigation (Section 5.3). Alpha-beta scan data will also be used to verify the assumptions for the relative shift and revise the number of static measurements for each SU, if necessary (Section 4.4.1).

4.6.3.3 Survey Unit Systematic Alpha-Beta Static Measurements

Static measurements will be performed at each systematic static location and will total 14 in each SU and the RBA, or the revised number determined in Section 4.4.1. Locations that pose safety concerns or obstructions will be relocated to the nearest accessible location and noted on the field measurement forms. Each static measurement will be performed in scaler mode for a count duration sufficient to ensure that the alpha static MDC and beta static MDC are equal to or less than the RG_{α} and RG_{β} for the building, respectively. A DQA of the static measurement data

(Section 5.2) will identify locations that exceed the applicable alpha or beta static IL (Section 4.5.8.6) and, therefore, require further investigation (Section 5.3) or remediation.

4.6.3.4 Biased Alpha-Beta Static Measurements

Biased static measurements will be used to further investigate areas with potential elevated surface activity, as indicated by beta scan data exceeding the beta scan IL or systematic static data exceeding the applicable alpha or beta static IL. The survey meter will be operated in scaler mode and measurements will be made for the same count duration as that for the systematic static measurements.

4.6.3.5 Alpha-Beta Swipe Samples

Swipe samples will be taken at all locations of systematic and biased static measurements. They will be taken dry, using moderate pressure, over an area of approximately 100 cm^2. Swipe samples will be measured for gross alpha and beta activity using a Ludlum Model 3030 or equivalent. In addition to comparison with the RGs for removable contamination, the surface activity on the sample will be compared to the total surface activity measured by the static measurement to assess the removable fraction of surface activity. This information will be used in any dose or risk assessment performed.

4.6.3.6 Survey Unit Gamma Scanning

The floor surfaces of Survey Units 1-13 in Building 414 will be gamma scan surveyed using the soil core gamma scanning instrumentation identified in Section 3.5.1 (Eagle iScan^{SM} handheld system). One hundred percent of the accessible floor surfaces of Survey Units 1-13 in Building 414 (soil/gravel material) will be gamma scan-surveyed using the Eagle iScan^{SM} handheld system, equipped with a gamma scintillator, real-time gamma spectroscopy and data logging.

Assuming GPS reception is not available, a reference coordinate system will be established to document gamma scan measurement locations. The reference coordinate system will consist of a grid of intersecting lines referenced to a fixed site location or benchmark. If practical, the coordinates of the fixed location or benchmark will be recorded.

The data collected during the gamma scan using the Eagle iScan^{SM} are evaluated as described in Section 3.5.1.1. Data sets will be transferred from the data logger onto a personal computer to create spreadsheets and, if feasible, gamma scan survey results will be mapped. Data obtained during the surface gamma scan surveys, including gross gamma, and individual radionuclide spectral measurements, will be analyzed to identify areas where surface radiation levels appear to be greater than the radionuclide-specific ILs using ROI-peak identification tools.

If gamma scan surveys indicate areas of potentially elevated activity in soil above the ILs (Section 3.3.1), then an investigation of the potential area of elevated activity will be initiated. At a minimum, the gamma scan data and collection of biased soil samples will be conducted. The biased soil sample will be collected from the approximate location of the highest elevated gamma scan survey measurement. If areas displaying elevated activity are collocated, then an attempt will be made to locate the area with the highest gamma scan results and designate it as the biased sample location to represent the collocated elevated areas. Potentially elevated material will remain segregated until completion of the investigation activities.

4.6.3.7 Survey Unit Soil Sampling

Following completion of the surface gamma scan survey of Survey Units 1-13 in Building 414, elevated areas noted on a survey map will be investigated. Biased samples will be collected from potential areas of elevated activity displaying gamma scan survey results greater than the IL (Section 5.3.1).

Following the completion of the gamma scan surveys, the SU area will be plotted using VSP software (or equivalent) to determine the location of systematic samples. A stylized graphic of an example SU with 14 systematic sample locations is shown on **Figure 3-4**. The surface soil sample collection process is detailed in Section 3.6.5.1. The soil samples collected from each SU will be submitted to the off-site analytical laboratory for analysis in accordance with the SAP (**Appendix A**).

4.6.3.8 Assessment of Residual Materials and Equipment

Several buildings contain residual materials and/or equipment from past operations (e.g., piping, ventilation ducting, shelving, machinery, etc.) that will undergo radioactivity surveys in accordance with SOP RP-104, *Radiological Surveys*, and SOP RP-105, *Unrestricted Release Requirements* (**Appendix A**). These surveys may include a combination of surface scans and static measurements, swipe samples, and material samples. Sampling or survey points accessed during previous surveys will be used as a starting point, where possible. Surveys of impacted building material and equipment will be incorporated into the building SU. After data evaluation, disposition decisions, and subsequent investigation of the surfaces below the materials and equipment will be coordinated with the Navy.

4.6.3.9 Decontamination and Release of Equipment and Tools

Decontamination of mobilized materials and equipment may be necessary at completion of fieldwork if radioactive materials above RGs are encountered. Numerous decontamination methods are available for use. If practical, manual decontamination methods will be used. Abrasive methods may be necessary if areas of fixed contamination are identified. Chemical decontamination can also be accomplished by using detergents for nonporous surfaces with contamination present. Chemicals will be selected for decontamination that will minimize the creation of mixed waste. Decontamination activities will be conducted using SOP RP-132, *Radiological Protective Clothing Selection, Monitoring, and Decontamination* (**Appendix A**).

4.6.4 Demobilization

Demobilization will consist of surveying, decontaminating, and removing equipment and materials used during the investigations; cleaning and inspecting the project site; and removing temporary facilities. Survey of equipment and materials will be performed in accordance with Section 6.6, and decontamination will be performed in accordance with Section 3.6.7.2. Demobilization activities will also involve collection and disposal of contaminated materials, including decontamination water and disposable equipment for which decontamination is inappropriate (Section 7).

5.0 DATA EVALUATION AND REPORTING

Data from the radiological investigation will be evaluated to determine whether the site conditions are compliant with the Parcel E ROD RAO. If the residual ROC concentrations are below the RGs in the Parcel E ROD or are shown to be NORM or anthropogenic background, then the site conditions are compliant with the Parcel E ROD RAO.

Radiological surveys will include scan measurements of accessible surfaces combined with collection and analysis of samples and static measurements on building interior surfaces. Scan measurements are used to identify potential areas of elevated radioactivity for investigation using biased samples and static measurements and are not used to directly demonstrate compliance with the Parcel E ROD RAO. Sample and static measurement results at systematic, random, and biased locations are used to evaluate compliance with the Parcel E ROD RAO. A separate compliance decision will be made for each ROC for each sample and static measurement.

In general, the following actions will occur during data evaluation and reporting:

- Scan data will be evaluated to identify potential areas of elevated activity for additional investigation, as follows:
  - Confirm that required scan surveys have been performed on accessible surfaces as described in Section 3 for soil and Section 4 for buildings.
  - Scan data will be verified as described in the SAP (**Appendix A**).
  - DQA will be performed on scan data as described in Section 5.2.
  - Potential areas of elevated activity will be identified as described in Section 5.3.1.
  - Potential areas of elevated activity will be investigated as described in Section 5.3.2.
- Soil sample and static measurement data will be evaluated to determine whether site conditions comply with the Parcel E ROD RAO, as follows:
  - Confirm that required soil samples have been collected from systematic and biased locations as described in Section 3 and required building measurements have been performed as described in Section 4.
  - Confirm that samples have been submitted to the laboratory and backup samples have been archived in a secure area under chain-of-custody protocols.
  - Confirm that laboratory analyses have been performed as described in the SAP (**Appendix A**).
  - All analytical data will be validated by an independent third party.
  - DQA will be performed as described in Section 5.2.
  - Sample and direct measurement results will be compared to the corresponding RGs as described in Section 5.4.
  - Sample and direct measurement results will be compared to the appropriate RBA data from HPNS as described in Section 5.5.
  - Samples with gamma spectroscopy results that exceed the RG and the expected range of background for ^{226}Ra will be analyzed by alpha spectroscopy for uranium isotopes

(^{238}U, ^{235}U, and ^{234}U), thorium isotopes (^{232}Th, ^{230}Th, and ^{228}Th), and ^{226}Ra to evaluate the equilibrium status of the uranium natural decay series to determine whether ^{226}Ra is NORM as described in Section 5.6.

- Results of the investigation will be documented as described in Section 5.7.

5.1 Data Quality Validation

Analytical data validation will be performed by an independent third party as described in the SAP (**Appendix A**). Data validation will be performed on all TU/SU data and all RBA data.

5.2 Data Quality Assessment

The DQA is a scientific and statistical evaluation that determines whether the survey data are the right type, quantity, and quality to support the survey objectives (USEPA, 2006). There are five steps in the DQA process:

1. Review the DQOs and survey design.
2. Conduct a preliminary data review.
3. Select the statistical test.
4. Verify the assumptions of the statistical test.
5. Draw conclusions from the data.

The effort expended during the DQA should be consistent with the graded approach used to develop the survey design. The DQA process will be applied to all SU data and all RBA data.

5.2.1 Review the Data Quality Objectives and Survey Design

The sampling design and data collection documentation will be reviewed for consistency with the DQOs. At a minimum, this review will include:

- Number of soil samples or measurements in each SU;
- Location of soil samples and measurements;
- Measurement technique (i.e., scan, static, sample, or swipe) and instrumentation:
  - Measurement uncertainty,
  - Detectability (critical level and MDC),
  - Quantifiability; and
- Statistical power.

The purpose of the review should focus on identifying the information required to complete the evaluation of the data. A determination of whether the survey objectives were achieved will be completed during Step 5 of the DQA Process (see Section 5.2.3).

5.2.2 Conduct Preliminary Data Review

A preliminary data review will be conducted to learn about the structure of the data by identifying patterns, relationships, or potential anomalies. The preliminary data review will include the following:

1. Calculate statistical quantities,

2. Prepare posting plots of scan and sample data,
3. Prepare histograms of scan and sample data,
4. Prepare quantile-quantile (Q-Q) plots (sometimes referred to as normal probability plots) of scan and sample data,
5. Prepare box plots of scan and sample data,
6. Prepare retrospective power curves, and
7. Analyze data distributions.

If additional data evaluation tools are used to support conclusions concerning compliance with the Parcel E ROD RAO, then the report will provide a complete description of the evaluation performed and any assumptions used. For example, if a contour plot is provided to describe site conditions, then the report would contain a description of the contouring technique used, a list of parameter values and assumptions used to prepare the contour plots, a copy of the contour plot, and an interpretation of the contour plot relative to compliance with the Parcel E ROD RAO.

5.2.2.1 Convert Survey Results

The RGs for soil (**Table 3-5**) are stated in units of pCi/g, and soil sample results from analytical laboratories will be reported in units of pCi/g; therefore, no conversion will be necessary for soil sample data.

The RGs for buildings surfaces (**Table 4-2** and **Table 4-3**) are stated in units of dpm/100 cm^2; however, alpha and beta static measurement results will be reported in units of counts during a specified counting interval, while scan measurement results will be reported in units of cpm. Example ILs for alpha and beta scan measurements are provided in **Table 4-7**, where the RGs have been converted into cpm using **Equation 4-2** and example total efficiencies from **Table 4-6**. Example ILs for alpha and beta static measurements are provided in **Table 4-9**, where the RGs have been converted into counts using **Equation 4-8** and example total efficiencies from **Table 4-6**. Instrument-specific total efficiencies and material-specific backgrounds will be determined in the field, along with instrument-specific ILs corresponding with the RGs for alpha and beta static and scan measurements on building surfaces.

Once all the survey results and RGs are available in the same or comparable units, the evaluation of the data can continue.

5.2.2.2 Calculate Statistical Quantities

The mean, median, standard deviation, minimum, and maximum for each data set will be reported. Other statistical quantities that may be reported to describe individual data sets include percentiles (25th and 75th for interquartile range, 95th and 99th for upper bound estimates), skewness (a measure of deviation from normal), coefficient of variation, and total number of data points in the data set.

5.2.2.3 Prepare Posting Plots

Posting plots are maps on which measurement results are shown at the location where the measurement was performed. Posting plots will be prepared for scan survey data, and static and swipe data from biased, systematic, and random locations on building surfaces. Posting plots of soil sample locations may also be prepared for Phase 1 TUs, Phase 2 TUs, and surface soil SUs. Posting plots will be prepared for each SU but are not required for each RBA.

Posting plots are inspected to identify patterns or inconsistencies in the data, especially potential areas of elevated activity requiring additional investigation or spatial trends identifying survey data that are not independent, violating the assumptions of the statistical tests. Posting plots may be prepared using counts, count rates, concentrations, or normalized data (standard deviations or z-scores) allowing comparison of results from multiple detectors or different measurement methods. Posting plots are most useful when presented in the same units as the RGs or ILs being evaluated.

5.2.2.4 Prepare Histograms

Histograms, or frequency plots, are used to examine the general shape of a data distribution. Histograms will be prepared for scan survey data, static and smear survey data from systematic and random locations, and soil sample data from systematic locations for each SU and RBA. Biased survey data do not need to be included when preparing histograms; however, care should be taken when interpreting histograms that include data collected from biased locations. Histograms reveal obvious departures from symmetry, including skewness, bimodality, or significant outliers.

5.2.2.5 Prepare Q-Q Plots

Q-Q plots compare a data distribution to an assumed normal distribution. Q-Q plots will be prepared for scan survey data, static and smear survey data from systematic and random locations, and soil sample data from systematic locations for each SU and RBA. Biased survey data do not need to be included when preparing Q-Q plots; however, care should be taken when interpreting Q-Q plots that include data collected from biased locations.

Background data usually approximate a normal distribution, so comparing SU data to a normal distribution is one technique in comparing survey data to background. Data from a normal distribution appear as a straight line on a Q-Q plot, so deviations from a straight line indicate potential deviations from a normal distribution, or potential deviations from background. Normal probability plots from different data sets, such as a SU and an RBA or adjacent SUs, can be shown on the same graph to allow for direct comparisons between multiple data sets.

5.2.2.6 Prepare Box Plots

Box plots are a non-parametric graphical depiction of numerical data based primarily on quartiles (25^{th}, 50^{th}, and 75^{th} percentiles). Box plots may include whiskers showing extreme values, usually the minimum and maximum. Box plots may also show outliers as individual points. The ends of the whiskers and selection criteria for outliers are not standardized and may represent different values depending on the underlying assumptions.

Box plots provide visual estimates of dispersion and skewness for a data set including the range, interquartile range, and median. Box plots from different data sets, such as an SU and an RBA or adjacent SUs, can be shown on the same graph to allow for direct comparisons between multiple data sets.

5.2.2.7 Prepare Retrospective Power Curves

A retrospective power curve provides an evaluation of the survey design and is used to demonstrate enough data were collected to support decisions regarding the radiological status of the SU. Retrospective power curves will be prepared for static and smear survey data from systematic and random locations, and soil sample data from systematic locations for each SU. Biased survey data will not be included when preparing retrospective power curves. The retrospective power curve is compared with the DQOs (Section 3.1 and Section 4.1) and the Type II decision error rates from Section 4.4.6 of the Basewide Radiological Management Plan (TtEC, 2012), to evaluate whether a sufficient number of samples was collected.

No statistical tests are required for individual data sets because compliance with the Parcel E ROD RAO is based on point-by-point comparisons. Because the number of measurements per SU was determined assuming that a statistical test would be performed, the retrospective power curve assists in determining whether the survey design was adequate and is not directly related to compliance decisions.

5.2.2.8 Analysis of Data Distributions

The distribution of data within a data set can provide important information during data evaluation. Determining the type of distribution may be important for selecting additional evaluation tools to answer specific questions about individual data sets. The analysis of data distributions for this investigation may be used primarily for establishing MLE values for RBA data sets.

Environmental data are most often associated with three distributions: normal, lognormal, or gamma. Statistical tests to identify a distribution have a null hypothesis that the data set comes from the distribution being tested. This means there must be sufficient evidence showing that the data do not follow a specific distribution before the initial assumption is rejected. For this reason, it is not unusual for a data set to be associated with more than one type of distribution. Moreover, negative values in a data set cannot provide results for analyzing lognormal or gamma distributions.

Individual data sets will be analyzed to determine whether the data appear to follow a normal, lognormal, or gamma distribution at a 5 % significance level using software such as ProUCL. Data sets that do not follow at least one of these distributions will be identified as not following any known distribution and will be evaluated using nonparametric tools and tests.

5.2.3 Draw Conclusions from the Data

Figure 3-1 and **Figure 4-6** present an overview of how decisions for soil and building data, respectively, are combined to draw a conclusion on compliance with the Parcel E ROD RAO. Each sample and static measurement result will be compared to the corresponding RG. If all residual ROC concentrations are less than or equal to the corresponding RG, then site conditions comply with the Parcel E ROD RAO.

Sample and measurement data will be compared to appropriate RBA data from HPNS, and multiple lines of evidence will be evaluated to determine whether site conditions are consistent with NORM or anthropogenic background. The data evaluation may include population-to-population comparisons, use of a MLE or BTV, graphical comparisons, and comparison with regional background levels. If all residual ROC concentrations are determined to be consistent with NORM or anthropogenic background, then site conditions comply with the Parcel E ROD RAO.

Each ^{226}Ra gamma spectroscopy result exceeding the ^{226}Ra RG and outside the expected range of background will be compared to concentrations of other radionuclides in the uranium natural decay series from the same sample. If the concentrations of radionuclides in the uranium natural decay series are consistent with the assumption of secular equilibrium, then the ^{226}Ra concentration is NORM, and site conditions comply with the Parcel E ROD RAO.

If the investigation results demonstrate that there are no exceedances determined from a point-by-point comparison with the statistically-based RGs[2] at agreed upon statistical confidence levels, or that residual ROC concentrations are NORM or anthropogenic background, then a RACR will be developed.

If the investigation results demonstrate exceedances of the RGs determined from a point-by-point comparison with the statistically-based[1] RGs at agreed upon statistical confidence levels and are not shown to be NORM or anthropogenic background, then remediation may be required. Remediation activities, if warranted, would be described in an addendum to this RSEWP and would be conducted in accordance with applicable elements of the MARSSIM. The RSEWP Addendum would include details for any appropriate remedial action support. If remediation is conducted, then a RACR will be prepared after the remediation activities have been completed. The RACR will describe the results of the investigation, explain remediation performed, compare the distribution of data from the sites with applicable reference area data, and provide a demonstration that site conditions are compliant with the Parcel E ROD RAO through the use of multiple lines of evidence including application of statistical testing with agreed upon statistical confidence levels on the background data.

5.3 Investigation of Potential Areas of Elevated Activity

The investigation of potential areas of elevated activity consists of comparing each measurement result from every SU with the ILs discussed in Section 3.3.1 for soil, Section 4.5.8.2 for building scans, and Section 4.5.8.6 for building static measurements. In general, the ILs are consistent with the RG values. This investigation is performed for all measurement results of scans, static measurements, and samples at systematic, random, and biased locations. The investigation of potential areas of elevated activity ensures that unusually high measurement and sample results will receive proper attention, and any area having the potential for significant contributions to total dose will be identified.

5.3.1 Identify Potential Areas of Elevated Activity

Scan data, measurement data, and sample data will be evaluated to identify statistical and spatial anomalies indicating potential areas of elevated activity. All scan data will be compared directly to RGs or ILs. Posting plots will be used to identify trends and patterns in the scan data to help in

[1] The RGs are statistically based because they are increments above a statistical background.

identifying potential areas of elevated activity and support defining the areal extent of potential areas of elevated activity. Histograms and Q-Q plots will be used to identify significant outliers and evidence of multiple distributions to identify potential areas of elevated activity. Any sample or measurement exceeding a ROC-specific RG will be investigated as a potential area of elevated activity. In addition, SU areas with multiple lines of evidence indicating a potential increase in localized activity based on posting plots, histograms, and Q-Q plots of scan, static measurement, or sample data will be investigated as a potential area of elevated activity.

If direct measurement or sample results exceed the RG or IL for a specific ROC for locations not identified by scan survey, then the scan survey technique will be reviewed and investigated to determine whether the scan survey was implemented correctly and whether the scan methodology met the survey objectives.

5.3.2 Investigate Potential Areas of Elevated Activity

The objective of investigating potential areas of elevated activity is to characterize the ROCs present and the size, or extent, of all areas of elevated activity. To accomplish this objective, a minimum of one potential area of elevated activity will be investigated in every SU. If no potential areas of elevated activity are identified in a TU/SU based on Section 5.3.1, then the location of the maximum scan result will be identified as a potential area of elevated activity.

The first step in investigating potential areas of elevated activity is to confirm the measurement or sample results that indicated the potential area of elevated activity. For alpha and beta scans, this may be accomplished by pausing during scanning to collect additional information, or it may require returning to a location to perform a biased static measurement. For gamma scans this may involve rescanning the area surrounding the potential elevated reading, sifting through near surface soil for a discrete source of activity (e.g., deck marker), or collecting a biased soil sample for analysis. The selection of the confirmatory action will depend on the initial results and the decision on whether the original results are confirmed. In general, minimal information is acceptable when deciding to continue with the investigation of a potential area of elevated activity. In most cases, at least one measurement or sample result documenting the lack of elevated activity will be required to support a decision to terminate the investigation of a potential area of elevated activity.

Once the presence of an area of elevated activity has been confirmed, the ROCs present will be identified. In most cases the identification of ROCs can be accomplished using existing data. For building surfaces, it is sufficient to identify the elevated activity as alpha, beta, or a combination of alpha and beta radiation. For soil samples, it is generally necessary to identify the radionuclide based on laboratory analysis.

The final step in investigating areas of confirmed elevated activity is determining the area, or extent, of the elevated results. The identification of the ROCs present will assist in determining whether additional data are required to determine the extent of elevated activity, and the number and type of measurements or samples that will be used for that determination. For building surfaces, the posting plot of the scan data is generally all that is needed to determine the extent of elevated readings. The determination may be accomplished similarly for soil areas when the ROC is ^{226}Ra and the elevated activity is readily detected by scan surveys. Determining the extent of elevated activity for ROCs without a significant gamma emission, such as ^{90}Sr and ^{239}Pu, will require collecting additional soil samples or establishing a correlation between the difficult-to-detect ROC and ^{226}Ra. Even when a correlation can be determined, the scan survey objectives will need to be reviewed and adjusted to account for detecting ^{226}Ra at lower activity levels. For SFUs with elevated activity requiring further investigation, the entire surface area of the SFU will be investigated. If the elevated activity is associated with ^{90}Sr or ^{239}Pu results significantly above background, then a Field Change Request will be initiated to document the characterization of any potential areas of elevated activity. The results of the investigation should identify an area of elevated activity bounded by measurements or sample results below the RGs or ILs.

If all alpha or beta static measurement or ROC-specific soil sample analytical results are less than the RGs or ILs, then compliance with the Parcel E ROD RAO is achieved.

5.4 Comparison to RG Values

The Parcel E ROD establishes RGs for soil and building surfaces. These RG values are provided in **Table 3-5** for soils and **Tables 4-2** and **4-3** for building surfaces. Analytical data from systematic and biased surface and subsurface soil sample results will be compared directly with the RGs listed in **Table 3-5**. The analytical results from the analyses types specified in Section 3.7 will be compared directly with the RGs listed in **Table 3-5** to determine compliance with the Parcel E ROD RAO.

^{137}Cs is considered to be the indicator for all fission product radionuclides associated with NRDL activities. The limited number of systematic samples analyzed for ^{90}Sr and ^{239}Pu will serve to supplement the investigation. Sample results above the ^{137}Cs RG will trigger additional analyses in the same sample for ^{90}Sr or ^{239}Pu. The results of these additional analyses will be compared directly with the corresponding RG value for ^{137}Cs, ^{90}Sr, and ^{239}Pu. Based on the inability to perform gamma scanning for these radionuclides at the RG, demonstrating compliance with the Parcel E ROD RAO will be based on soil sample analytical results.

The RGs for building surveys are listed in **Table 4-2**. Static measurement results will be provided for total alpha and total beta activity and are not radionuclide specific. Therefore, the lowest RG values for alpha and beta emitting ROCs will be selected and are listed in **Table 4-3**. Total alpha and total beta results will be corrected for material-specific background and reported as net activity above the mean activity for that material from the RBA representing background for a specific building, on a specific material, using a specific detector. The net total activity will be compared directly with the corresponding RG.

If all sample and direct measurement results are less than or equal to the corresponding RG, then the site conditions are compliant with the Parcel E ROD RAO, and a RACR can be prepared as described in Section 5.7.

5.5 Comparison to Background

Sample and static measurement data shown to be NORM or anthropogenic background comply with the Parcel E ROD RAO, even if the results exceed the corresponding RG value. In addition, to address CDPH requirements for radiological release specified in California Code of Regulations

Title 17, Section 30256, a comparison of site data with background will be performed.

RBA data sets for soil are presented in the *Final Background Soil Study Report, Base Realignment and Closure, Program Management Office West, Former Hunters Point Naval Shipyard, San Francisco, California* (CH2M, 2020). RBA data sets for building surfaces will be developed as described in Section 4.4.2 to provide building-specific, material-specific, and instrument-specific RBA data. Final selection of RBA data sets will be reviewed by the Navy.

The comparison of site data with background may include, but is not limited to, the following:

- **Population-to-population comparisons.** Site data sets may be compared with RBA data using parametric or nonparametric tests, depending on the distributions of the data. Following the performance of any population test, the underlying assumptions of the test will be verified.
- **Use of an MLE or BTV.** A point-by-point comparison of site data with the MLE or BTV may be performed if RBA data allow for calculation of those values. MLE values will be calculated using USEPA's ProUCL software.
- **Graphical comparisons.** Graphical representations of site and RBA data may be useful in visually comparing two or more data sets. Typical graphical tools include histograms, box-and-whisker plots, and probability plots.
- **Comparison with regional background levels.** As noted in Section 5.5, much of HPNS was constructed using fill materials from off-site sources. As such, soil conditions at the site are heterogeneous, and the on-site RBAs may not accurately capture background levels of ROCs for all soil types that may be present at HPNS. Where appropriate, available RBA data from other sources may be used for comparison with site data.

If all residual ROC concentrations are consistent with NORM or anthropogenic background, then site conditions comply with the Parcel E ROD RAO. If any ^{226}Ra gamma spectroscopy results for soil exceed the RG and the expected range of NORM concentrations, then the equilibrium status of the uranium natural decay series will be evaluated for the sample as described in Section 5.6.

5.6 Determine Equilibrium Status

The RBA data set for ^{226}Ra and other naturally occurring ROCs will be selected to represent as much of the soil at HPNS as practical. However, the history of HPNS shows that a wide variety of fill materials have been used as part of construction and maintenance activities over the life of the site. These fill materials may have a range of naturally occurring radioactivity, so an incorrect identification of fill material could result, with higher levels of NORM being identified as contamination. To avoid this situation, additional evaluation may be performed for samples in which the ^{226}Ra gamma spectroscopy result exceeds the RG and the expected range of background, but the sample could still indicate association with NORM instead of contamination.

The uranium natural decay series is one of the primordial natural decay series that are collectively referred to as NORM. The members of the uranium natural decay series are present in background at concentrations that are approximately equal, a situation referred to as secular equilibrium. Secular equilibrium for the uranium natural decay series is established over hundreds of thousands of years. Concentrations of ^{226}Ra higher than the concentrations of other members of the uranium natural decay series may indicate contamination, while ^{226}Ra concentrations consistent with other members of the series indicate natural background.

Determining the equilibrium status of the uranium natural decay series requires analyzing a sample for multiple radionuclides from the series using the same or comparable analytical techniques. Observed differences in concentrations result primarily from differences in concentrations, and the uncertainty is primarily associated with the analysis.

Radionuclides from the uranium natural decay series with ^{226}Ra as a decay product (i.e., ^{238}U, ^{234}U, and ^{230}Th) will be analyzed by alpha spectroscopy, along with ^{226}Ra. It is not necessary to analyze for the decay products of ^{226}Ra because these radionuclides re-establish secular equilibrium with ^{226}Ra over a period of several weeks. In addition, most of the ^{226}Ra decay products are not readily analyzed by alpha spectroscopy. If practical, the analyses will be performed using the same sample aliquot to reduce sampling uncertainty. The results of the four analyses will be compared. If the ^{226}Ra result is similar to the results for the other radionuclides, then the ^{226}Ra activity is NORM and complies with the Parcel E ROD RAO, and the equilibrium determination will be documented in the RACR. If the ^{226}Ra result is significantly greater than the results for the other radionuclides and exceeds the RG and the expected range of background, then the elevated ^{226}Ra level may be attributed to site contamination, and remediation may be required.

5.7 Reporting

Results of radiological investigations for buildings and TUs/SUs complying with the Parcel E ROD RAO will be documented in a RACR, and the buildings and TUs/SUs will be recommended for unrestricted radiological release. The RACR will describe the results of the investigation, provide visualizations of spatially correlated data, explain remediation performed (if any), compare the distribution of data from the sites with applicable reference area data, and provide a demonstration that site conditions are compliant with the Parcel E ROD RAO. The FSS results, including a comparison to background and discussion of any remedial activities performed as part of the investigation, will be included as an attachment to the RACR.

If the investigation results demonstrate that Parcel E conditions are not compliant with the respective RAO, then a removal site evaluation report will be prepared. The site investigation report will include recommendations for further action based on the most current EPA guidance.

6.0 RADIOACTIVE MATERIALS MANAGEMENT AND CONTROL

Project requirements, including personnel roles and responsibilities, required training, and health and safety protocols are presented in the RPP (**Appendix C** of this RSEWP). **Appendix C** also contains the Radioactive Material License and SOPs. This section provides a brief overview of the radioactive materials management and control for this project.

6.1 Project Roles and Responsibilities

The personnel responsible for the execution of site activities and program oversight is presented in the Organization Chart in the CQCP (**Appendix B)**. The Field Team Leader is responsible for overseeing all field activities for this project. The Field Team Leader will serve as the primary point of contact for scheduling and field-related issues. The Radiation Safety Officer (RSO) has overall responsibility for ensuring that fieldwork is conducted by trained staff in accordance with the Radioactive Material License and applicable plans and procedures.

The RSO will be supported by radiation protection staff to implement the requirements of the licensed SOPs and for conducting radiological data collection in accordance with Sections 3 and 4 of this RSEWP.

6.2 Licensing and Jurisdiction

The Radioactive Material License is State of California Radioactive Material License 8188-07 (dated March 20, 2018). The license is attached to this RSEWP in **Appendix C**. Under *10 Code of Federal Regulations* (CFR) 150.20, Perma-Fix holds a general license to conduct these licensed activities in areas of exclusive federal jurisdiction within the State of California. Authorization will be required from California to work in certain parcels at HPNS. Authorization will be requested and approved before the start of field operations.

The following are State requirements:

- Under the Radioactive Material License 8188-07, Section 16, Perma-Fix will submit an appropriate notification to the State of California at least 14 days before the start of work.
- Under the Radioactive Material License 8188-07, Section 17, Perma-Fix will obtain an appropriate agreement between EIP and the Navy. This agreement will be included in the Section 16 submittal.

Perma-Fix will request reciprocity from the NRC, using NRC Form 241, to utilize Perma-Fix's State of California Radioactive Material License in areas under NRC jurisdiction. The NRC requires notification a minimum of 3 days prior to beginning licensed activities.

Perma-Fix (and EIP) will be added to the base-wide Memorandum of Understanding (MOU) for Hunters Point prior to mobilization.

6.3 Radiological Health and Safety

Fieldwork will be conducted in accordance with Perma-Fix's State of California Radioactive Material License and associated SOPs. A list of the field radiological SOPs that provide the instructions for conducting field activities involving exposure to radiation and radioactive materials and copies of the SOPs are provided in **Appendix C**.

Prerequisites for the initiation of survey activities include review of this RSEWP, radiological evaluation of the designated work areas, and identification of potential safety concerns. Dose rate, contamination, and air monitoring, including initial baseline sampling to determine radiological background conditions, will be performed as necessary and in accordance with this RSEWP and the supporting procedural documents, including the SOPs in **Appendix C**. Radiation Work Permits (RWPs) will be prepared in accordance with SOP RP-103, *Radiation Work Permits Preparation and Use*. RWPs will be used to govern radiological health and safety. Personal protective equipment (PPE) levels will be assigned or modified, according to this RSEWP and the APP/SSHP, and included in SOP RP-132, *Radiological Protective Clothing Selection, Monitoring, and Decontamination,* such that they are protective of health and safety based on radiological considerations and physical and chemical safety issues. Radiological personnel will prepare, approve, and record monitoring records in accordance with SOP RP-114, *Control of Radiation Protection Records*.

Key radiological personnel are expected to have the requisite skills necessary to perform these functions. The key radiological personnel include the following:

- License RSO
- PRSO
- Project Manager for Perma-Fix
- Radiation Protection Supervisor
- RPTs

Roles may be combined as described in this RSEWP. Key personnel will be approved in advance by the project manager.

6.4 Radiation Protection

Appendix C contains the RPP, which includes key Perma-Fix RPP procedures. The RPP details requirements for activities conducted under the California Radioactive Material License and describes radiation safety practices referenced in the APP/SSHP and to be applied in the field. The RPP covers project activities that involve the use or handling of licensed by-product, source, or special nuclear material (hereinafter referred to as radioactive material); tasks with the potential for radioactive material to be present based on available data and historical records; and work in posted RCAs.

6.4.1 Radiological Postings

Radiological postings are used to delineate the RCAs necessary to conduct investigation activities. Radiological posting requirements are presented in SOP RP-102, *Radiological Postings* (**Appendix C**).

6.4.2 Internal and External Exposure Control and Monitoring

Based on review of historical data, radiation doses are not expected to exceed 100 millirems per year (annual public dose allotment) for any project personnel. Although worker doses are expected to be a small fraction of the annual limits, external dose rates and cumulative doses and internal doses, via airborne concentration measurements, will be monitored to ensure that worker doses are maintained as low as reasonably achievable (ALARA). The dosimetry requirements are contained in SOP RP-112.

With the exception of untrained, escorted individuals as described in Section 6.4.3, all personnel entering the controlled area will be assigned an external monitoring device, such as a thermoluminescent dosimeter. Untrained, escorted personnel entering the controlled area will be logged such that the escort thermoluminescent dosimeter badge results can be used as the monitoring results for that untrained, escorted individual, in case a question arises regarding the possible external dose that individual received. Periodic external dose rate measurements will be taken before and during intrusive activities in accordance with SOP RP-104, *Radiological Surveys* (**Appendix C**), to ensure that worker exposures are maintained ALARA.

6.4.3 Radiological Access Control

Access control is necessary to provide a consistent methodology for controlling the access of personnel, equipment, and vehicles into radiological areas. Access control points further control the release of the materials, tools, and equipment from radiological areas. Access control requirements are found in SOP RP-101, *Access Control* (**Appendix C**). Areas targeted for investigation as part of this plan, including the soil stockpiling areas and the RSY pads, will be established as RCAs. Personnel and equipment exiting the boundary of an RCA will be surveyed to ensure that their clothing, equipment, and vehicles do not leave the site with contamination.

An RWP is an administrative mechanism used to establish radiological controls for intended work activities. The RWP will provide information to workers on area radiological conditions and entry requirements including PPE. The following summarizes the RWP process for this project:

- RWPs will be prepared by the License RSO or designee.
- RWPs will be approved by the License RSO or designee.
- Expected levels of contamination and external exposure rates will be listed in the RWP.
- Current and expected radiological conditions will be listed in the RWP.
- PPE and monitoring requirements will be specified in the RWP.
- Special monitoring instructions, hold points, or action levels may be listed as a part of the RWP requirements.
- RWP approval duration will be for the expected length of the project or until radiological conditions change and a revision is needed.
- Work will be suspended where radiological conditions change such that PPE or monitoring requirements must change, until a new or revised RWP containing the new RWP requirements is issued.
- Personnel working in the area covered by the RWP will be briefed on the RWP requirements and sign an acknowledgment that they have received and understand the briefing.

RWP requirements are found in SOP RP-103, *Radiation Work Permits Preparation and Use* (**Appendix C**).

6.4.4 Personal Protective Equipment

PPE will be selected based on the specific hazard and will comply with the APP/SSHP, the RWP, and the AHA specific to the task being performed. Based on historical information, the planned investigation activities are not expected to encounter or generate removable or airborne radioactivity. Therefore, it is expected that fieldwork PPE will consist of wearing Level D PPE and will include the following:

- Long pants
- High visibility outer layer
- Safety-toed boots
- Hard hat
- Work gloves
- Eye protection

If the field conditions exceed action levels for additional response, as detailed in Perma-Fix SOP RP-101, *Access Control*; SOP RP-102, *Radiological Postings*; and SOP RP-103, *Radiation Work Permits Preparation and Use* (**Appendix C**), then PPE may be upgraded as necessary.

6.4.5 Instrumentation

Instruments to be used for worker protection and monitoring will include dose and exposure rate instruments, alpha-beta dual phosphor surface contamination detectors, handheld 2-inch by 2-inch NaI detectors for gross gamma investigations, and a dual phosphor alpha-beta bench top counter for analysis of surface swipe samples and air samples. Instruments will be operated in accordance with applicable instrument-specific SOPs.

All counting systems and instruments will be calibrated with a National Institute of Standards and Technology-traceable source at intervals not exceeding 12 months, or as recommended by the manufacturer. The source used will be appropriate for the type and the energy of the radiation to be detected. All calibrations will be documented and include the source data.

The minimum training requirements for personnel working in the field at HPNS are provided in the following sections.

6.4.6 Radiological Training

Radiological training includes the following modules in accordance with SOP RP-115, *Radiation Worker Training* (**Appendix C**):

- General Employee Radiological Training
- Radiological Worker Training and Certification
- RPT Training and Certification

Visitors and escorted persons must receive a site briefing and will be assigned to a qualified radiation worker or RPT when in a posted RCA.

6.4.7 Health and Safety Training

Health and safety training may include, but is not limited to, the following:

- Occupational Safety and Health Administration (OSHA) 40-hour Hazardous Waste Operations and Emergency Response (Hazardous Waste Operations and Emergency Response [HAZWOPER]) training
- OSHA 8-hour HAZWOPER refresher training
- OSHA 8-hour HAZWOPER supervisor training
- OSHA-required On-the-Job training
- RAD Worker II Training
- Site-specific or task-specific AHA training
- Basic first aid training
- Cardiopulmonary resuscitation training

6.5 Radiological Support Surveys

Personnel, equipment, material, and area surveys will be performed in accordance with this RSEWP and the attached appendixes. If survey results indicate levels of surface contamination, appropriate decontamination methods will be implemented in accordance with applicable SOPs (**Appendix C**).

6.5.1 Personnel Surveys

Personnel surveys will be conducted in accordance with SOP RP-104, *Radiological Surveys* (**Appendix C**). Personnel surveys are used to ensure that individuals leaving a radiological area are free of contamination. Hands and feet will be scanned with dual alpha-beta scintillators when an individual exits an RCA. Scanning will be performed in the alpha plus beta mode of the instrument because of the potential presence of ^{90}Sr, a pure beta emitter, and the fact that beta particles are emitted from progeny in the radium decay chain that can be used as a surrogate for potential radium contamination. If contamination is found or suspected, then the PRSO will be contacted. The PRSO will provide further technical direction for any personnel/clothing decontamination that may be needed.

6.5.2 Equipment Surveys

6.5.2.1 Swipe Samples

Swipe sampling will be conducted to assess the presence of radioactive contamination that is readily removed from a surface. Swipe samples will be taken to evaluate the presence of removable alpha and beta activity. The procedures for collecting swipe samples are discussed in SOP RP-104, *Radiological Surveys* (**Appendix C**).

6.5.2.2 Exposure Rate Surveys (Dose Rates)

Exposure rate surveys are performed to measure ambient gamma radiation levels. Exposure rate surveys will be performed prior to and periodically during intrusive activities to confirm exposure levels relative to RWP requirements.

6.5.2.3 Equipment Baseline and Unconditional Release Surveys

Equipment mobilized and demobilized from the site will undergo radioactivity surveys in accordance with RP-104 *Radiological Surveys* and RP-105 *Unconditional Release Requirements* (**Appendix C**). Baseline and Release surveys may include a combination of surface scans and static measurements using dual alpha-beta scintillators and swipe samples.

6.6 Documentation and Records Management

This section defines the standards for maintaining and retaining radiological records. Radiological records provide historical data, document radiological conditions, and record personnel exposure. Field documentation requirements are outlined in the SAP (**Appendix A**) and SOP RP-114, *Control of Radiation Protection Records* (**Appendix C**).

Radiological surveys will be performed and documented in accordance with SOP RP-106, *Survey Documentation and Review* (**Appendix C**). Sample collection, field measurements, and laboratory data will be recorded electronically to the extent practicable. Electronically recorded data and information will be backed up to a SharePoint site or equivalent on a nightly basis, or as reasonably practical. Data and information recorded on paper will be recorded using indelible ink. Both electronic and paper records of field-generated data will be reviewed by the PRSO or a designee knowledgeable in the measurement method for completeness, consistency, and accuracy. Data manually transposed to paper from electronic data collection devices will be compared to the original data sets to ensure consistency and to resolve noted discrepancies. Electronic copies of original electronic data sets will be preserved on a nonmagnetic retrievable data storage device. No data reduction, filtering, or modification will be performed on the original electronic versions of data sets.

6.6.1 Documentation Quality Standards

Records will be legible and completed with indelible ink that provides reproducible and legible copies. Records will be dated and contain a verifiable signature of the originator. Errors that may be identified will be corrected by marking a single line through the error and by initialing and dating the correction. Radiological records will not be corrected using an opaque substance. Shorthand or non-standardized terms may not be used.

To ensure traceability, each record will clearly indicate the following:

- Name of the project
- Specific location
- Function and process
- Date
- Document number (if applicable)

The quantities used in records will be clearly indicated in standard units (e.g., curie, radiation absorbed dose [rad], roentgen equivalent man [rem], dpm, becquerel), including multiples and subdivisions of these units.

6.6.2 Laboratory Records

Survey and laboratory data assessment records will be prepared as indicated in the contractor's QA/QC Plan.

6.6.3 Record Retention

Records resulting from implementation of this RSEWP will be retained as outlined in Worksheet #29 of the SAP (**Appendix A**).

7.0 WASTE MANAGEMENT PLAN

This section describes the types of waste expected to be generated and the management, transport, and disposal of the waste materials.

7.1 Project Waste Descriptions

Waste generated during this investigation may be radiological in nature. The potential waste streams that will be generated and the management of those waste streams are addressed in **Table 7-1**. Waste streams that are not specifically identified in **Table 7-1** will be referred to the Environmental Manager.

The following sections address specific control and management practices for low-level radiological waste (LLRW) and non-radiological waste (non-LLRW). LLRW will be transferred to the Navy's radiological waste contractor, and disposed off site, in accordance with the terms of the MOU between Perma-Fix and the Navy's waste contractor. Waste determined to be non-LLRW will be transported and disposed of by EIP.

7.2 Radiological Waste Management

Waste materials deemed to be radioactive waste will be managed in accordance with the applicable license procedures, including SOP RP-111, *Radioactive Materials Control and Waste Management Program* (**Appendix C**).

7.2.1 Waste Classification

Accumulated waste deemed to be radioactive waste will be classified as LLRW based on 49 CFR, base wide requirements, or disposal facility requirements. Waste characteristics, including the radionuclides present and their associated specific activities, will be measured by an available standardized test method in accordance with the SAP (**Appendix A**), such as gamma spectroscopy, strontium analysis, or alpha spectrometry.

7.2.2 Waste Accumulation and Storage

Soil, debris, water, and materials classified as LLRW may be generated during sampling. When classified as LLRW, these wastes may be placed in containers provided by the Navy (55-gallon drums, super sacks, or equivalent). When filled, LLRW containers will be transferred to the custody and control of the Navy's radiological waste contractor, who will provide brokerage services including waste characterization sampling, transportation, and disposal in accordance with federal regulations and disposal facility requirements. Containers will be properly lined and an absorbent will be used if it is considered necessary. Containers will be radiologically surveyed when filled with material. Each container will be properly inventoried and labeled. Inventories will include material description and isotopic identification, and hazardous components, if appropriate. The contents of each container will be recorded in the field logbook, and each container will be assigned a unique identification number.

Containers will be stored in a designated and posted radioactive material storage area under the authority of the Navy's radiological waste contractor's California Radioactive Material License.

Storage areas may be at the site where the waste originated or another location as directed by the Navy. Containers will be secured to prevent unauthorized access to their contents. Once filled, containers will be surveyed, and surface radiation dose rate measurements will be collected.

7.2.3 Labeling and Posting of Containers Containing Radioactive Waste

Each waste container containing LLRW will be labeled. The activity contained in each waste container will be reported in pCi/g, and maximum contact radiation levels will be measured in milliroentgens per hour. Following the surveying and labeling, the waste container will be placed in a designated and posted radioactive area. The container area will be posted with a "Caution – Radioactive Materials Area" posting. An inventory of contents with radionuclide and specific activity (if available) will be maintained by EIP until the custody of the material is transferred to the Navy's radiological waste contractor.

7.2.4 Waste Accumulation Areas

At a minimum, the following requirements will be implemented for radioactive waste stored on site within a designated radioactive materials area:

- Industry standard posting and barrier materials will be displayed with wording that includes the following, "Caution – Radioactive Materials Area," at each radioactive waste storage area sufficient to be seen from any approach. The signs will be legible and clearly conspicuous for outdoor and indoor locations.
- Aisle space will be maintained to allow for the unobstructed movement of personnel, fire-control equipment, spill-control equipment, and decontamination equipment to any facility operation area, in the event of an emergency, unless aisle space is not needed for any of these purposes.
- Areas will be secured to prevent unauthorized access to the material.
- Emergency equipment will be located or available to personnel during radioactive waste management activities at each accumulation area, including:
  - A device, such as a telephone or a handheld two-way radio, capable of summoning emergency assistance (adjacent areas with personnel who have communication devices or areas with fixed devices that personnel can access quickly are sufficient)
  - Portable fire extinguishers, fire-control equipment, spill-control equipment, and decontamination equipment

Filled containers generated during performance of work will be stored in a material storage location until the contained material can be characterized and appropriately classified. Depending on the characterization results, the material may be moved to another storage location, transported and disposed off site, or reused as backfill.

7.2.5 Inspection of Waste Accumulation Areas

While all waste accumulation areas will be informally inspected daily during waste generation activities, formal inspections of all container accumulation areas will be conducted and recorded at least weekly in accordance with the appropriate Radioactive Material License requirements. The PRSO or designee will conduct inspections that will be recorded in a dedicated field logbook, and a weekly inspection checklist will be completed. The container storage areas will be inspected and the containers will be checked to ensure the following:

- Containers will be checked for condition. If a container is not in good condition, then the certified waste broker will be informed.
- Containers will be checked to ensure that they remain closed and secured at all times, except when adding or removing waste.
- Container label will be checked to ensure that it is visible, legible, and filled out properly.

7.2.6 Waste Transportation

In accordance with the MOU, the Navy's radiological waste contractor will be responsible for transportation of the LLRW in accordance with the United States Department of Transportation (DOT) Radioactive Material Transportation regulations of 49 CFR for off-site disposal. The Navy's radiological waste contractor may supply DOT contamination surveys and radiation measurements on the outside of the container prior to shipment and will ensure that empty containers being returned to vendors meet the release limits for equipment and materials.

LLRW transported from the site will be accompanied by a radioactive waste manifest or a Uniform Hazardous Waste Manifest, as appropriate. Preparation of the LLRW manifests are the responsibility of the Navy's radiological waste contractor. BRAC will receive a copy of the manifest. The remaining copies will be given to the transporter. The manifest will be returned to the Navy signatory official in accordance with the Base's recordkeeping requirements.

7.2.7 Waste Disposal

The Navy's radiological waste contractor is responsible for the disposal of LLRW. The Navy's radiological waste contractor will coordinate closely with RASO and contractor to ensure proper transfer of custody of the waste and coordinate the shipment off site. LLRW inventories will be managed under the appropriate Radioactive Material License.

7.3 Non-radiological Waste Management

7.3.1 Waste Classification

In general, wastes generated during the project will be assessed to determine proper handling and final disposition through chemical analysis, field testing, and possible generator knowledge. The exceptions are uncontaminated wastes (i.e., no contact with contaminated media or remediation chemicals) and trash.

Samples of these wastes will be collected and analyzed to determine whether the waste is a Hazardous Waste or a Nonhazardous Waste. Analysis will be based on the requirements of the off-site disposal facility and may include total petroleum hydrocarbons (typically C_4 to C_{40}), volatile organic compounds (VOCs), semi-volatile organic compounds, corrosivity (pH), and/or California Assessment Manual 17 total metals. Based on the results, additional waste characterization may be needed or necessary to have the waste managed at an off-site waste management facility. The project Environmental Manager will review the analytical data and characterize and classify the waste.

Samples will be collected in accordance with the general procedures in the following section and sent to a properly licensed laboratory for analyses. If the waste is placed in containers, then one composite sample (and one grab for VOC analysis, if needed) will be collected for every 10 drums of each waste stream. If soil is staged in stockpiles or bins, then a 4-to-1 composite sample will be collected; a grab sample also will be collected for VOCs. If the waste (liquid) is placed in a tank or container, then grab samples are appropriate. Off-site waste management facilities may require specific sampling per volume of waste accumulated under their waste acceptance policy.

7.3.2 Waste Sampling Procedures

7.3.2.1 Liquids

Analytical samples for liquid wastes will be collected from the 55-gallon drums before disposal; one composite sample will be collected for every 10 drums. Water samples will be collected by the following procedure:

1. Collect a water sample from a drum using a bailer or dipper if the water is homogenous or use a coliwasa if the water has more than one phase.
2. Fill the sample containers for volatile organic compound analyses first; fill the 40-milliliter vials so there is no headspace in each vial.
3. Fill the sample containers for the remaining analyses.
4. Label and package the sample containers for shipment to the laboratory.

7.3.2.2 Solids

For soil, one grab sample and one composite sample will be collected for every 10 drums. Soil samples procedures for collecting VOC samples are as follows:

1. Retrieve a core from the selected sample location.
2. Fill the appropriate sample jars completely full, with the sample from the core.

Soil sample procedures for collecting nonvolatile or metal samples are as follows:

1. Collect equal spoonfuls of soil from five randomly selected points and transfer into a stainless-steel bowl.
2. Use a stainless-steel spoon and quartering techniques to homogenize the five samples.
3. Fill the appropriate sample jars completely with the homogenized sample.
4. Close the jars, label them, complete chain-of-custody documentation, and package them for shipment to the laboratory.

7.3.3 Waste Profile

Waste characterization information will be documented on a waste profile form provided by the off-site treatment or disposal facility and reviewed by a project Environmental Manager before being submitted to the Navy. The profile will be reviewed, approved, and signed by the appropriate Navy personnel. Signed profiles will then be submitted to the designated off-site facility.

The profile typically requires the following information:

- Generator information, including name, address, contact, and phone number
- Site name, including street/mailing address
- Process-generating waste
- Source of contamination
- Historical use for area
- Waste composition (e.g., 95 % soil and 5 % debris)
- Physical state of waste (e.g., solid, liquid)
- Applicable hazardous waste codes
- DOT proper shipping name.

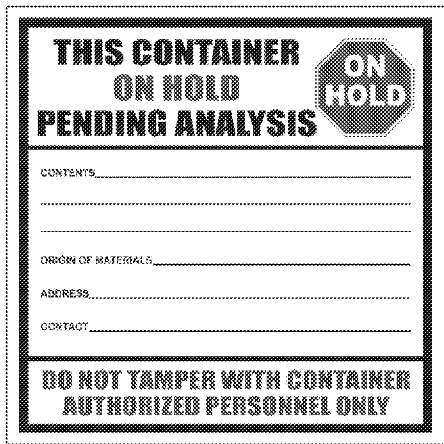
The contractor will coordinate with the disposal subcontractor to schedule the transportation of the waste to the off-site disposal facility after the copy of the approved waste profile is received.

7.3.4 Container Labeling

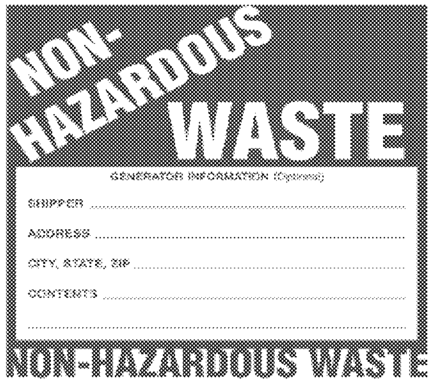
Each waste container containing contaminated media will be marked and labeled upon use concerning the contents in the container. Each hazardous waste container will be marked in accordance with 22 California Code of Regulations 66262.32. In addition, containers will be labeled in accordance with DOT 49 CFR 172.300 (Marking) and 172.400 (Labeling) and 40 CFR Subpart C. DOT labeling is only required before offering transportation off site.

The marks will note the type of waste, location from which the waste was generated, and accumulation start date. One of the following labels will be used:

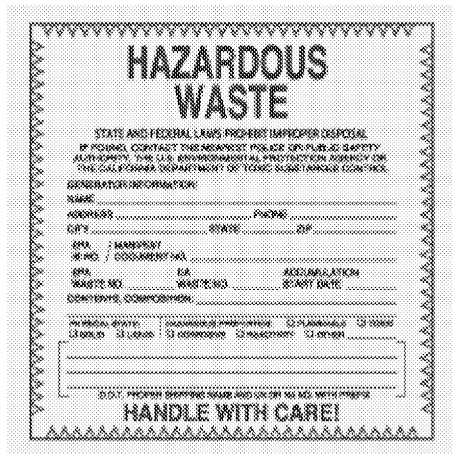
- **"Analysis Pending" or "Waste Material"** — Temporary label until analytical results are received, reviewed, and determined whether the waste is hazardous or not. This label (shown on the right) will include the following information:
  - Contents: *Example – soil from drill/auger cuttings*
  - Origin of Materials: Former Hunters Point Naval Shipyard
  - Address:
  - Contact Name and Phone Number:
  - Accumulation Start Date: *Add under the Contact line*



- "**Non-Hazardous Waste**" — If the waste is determined to be non-hazardous, then the label shown on the right will be applied with the following information:
  - Shipper: Former Hunters Point Naval Shipyard
  - Address:
  - Contents: *Example – soil from drill/auger cuttings*
  - Contact Name and Phone Number:
  - *Add Accumulation Start Date somewhere on the label*



- "**Hazardous Waste**" — If the waste is determined to be hazardous, then the label shown on the right will be applied with the following information:
  - Name: Former Hunters Point Naval Shipyard
  - Address:
  - Phone:
  - City: San Francisco
  - State: CA
  - Zip:
  - USEPA ID No.:
  - Manifest number: *Add before transportation*
  - USEPA Waste No.: *Environmental Manager to provide*
  - CA Waste No. *Environmental Manager to provide*
  - Accumulation Start Date: *The date the waste was first placed in the container*
  - Physical State: *Check solid or liquid*
  - Hazardous Properties: *Check the appropriate hazard*
  - DOT proper shipping name: *Environmental Manager to provide*



If additional assistance is needed in selecting the appropriate marks and labels, please contact the Environmental Manager or waste expert.

7.3.5 Waste Accumulation Areas

If hazardous waste is generated, then EIP will coordinate with the Navy to determine an appropriate site location to store the hazardous waste.

All containers will be physically handled in accordance with the APP/SSHP. Additional management requirements for the containers expected to be used are provided in **Table 7-2**.

Table 7-2. Non-LLRW Accumulation Requirements

Accumulating In:	Requirements
Drums/Small Containers	• Inspected on site upon arrival for signs of contamination or deterioration. Any container arriving with contents or in poor condition will be rejected. • No penetrating dents are allowed that could affect the integrity of the drum. Pay special attention to dents at the drum seams. • Closed head drums will be inspected to verify that the bung will close properly. • Open head drums will be inspected to verify that the drum lid gasket is in good shape and that the lid will seat properly on the drum. • Arranged in rows of no more than 2 drums with at least 3 feet between rows. • Each container will be provided with its own mark and label, and the marks and labels must be visible. • Drums will remain completely closed with all lids, covers, bolts, and locking mechanisms engaged, as though ready for immediate transport, except when removing or adding waste to the drum. • Drums and small containers of hazardous waste will be transported using proper drum-handling methods, such as transportation by forklift on wood pallets, with drums secured together. Containers will be transported in a manner that will prevent spillage or particulate loss to the environment. • Drums will be disposed of with the contents. If the contents are removed from the drums for off-site transportation and treatment or disposal, then the drums will be decontaminated prior to reuse or before leaving the site. • The outsides of the drums and containers must be free of hazardous waste residues. • Ignitable or reactive wastes will be stored at least 50 feet from the property line. • Drums and containers will not be located near a stormwater inlet or stormwater conveyance. • Drums containing waste liquids, hazardous or incompatible wastes will be provided with secondary containment capable of holding the contents of the largest tank and precipitation from a 24-hour, 25-year storm. • Liquid that accumulates in a secondary containment area will be removed and placed in containers within 24 hours. Removed liquids with a sheen will be characterized and classified. • New empty drums will be marked with the word "Empty". Drums that are being reused will be marked with "Empty, last contained [previous contents]" • All containers will be tracked on the field transportation and disposal log

7.3.6 Inspection of Waste Accumulation Areas

Waste container accumulation areas will be inspected at least weekly for conditions that could result in a release of waste to the environment. Inspections will focus on conditions such as equipment malfunction, container or containment deterioration, signs of leakage or discharge. Containers (drums and roll-off bins) will be inspected for leaks, signs of corrosion, or signs of general deterioration.

Any deficiencies observed or noted during inspection will be corrected immediately. Appropriate measures may include transferring waste from a leaking container to a new container, replacing the liner or cover, or repairing the containment berm.

Inspections will be recorded in the project logbook or on an inspection form. Deficiencies and corrections will also be documented. All the following items will be noted in the logbook for each inspection:

- Location of the area
- Total number of containers present
- Date
- Verification that all containers are labeled with the accumulation start date, contents, Base point of contact, and any relevant hazards (such as flammable and oxidizer). Labels must be visible, legible, and not faded.
- Condition of containers. Good condition for containers is defined as no severe rusting, dents, structural defects, or leaks.
- Condition of secondary containment. Good condition for containment is defined as no structural defects or leaks.
- Verification that all containers are completely closed with all bolts, lids, and locking mechanisms engaged as though ready for immediate transport.
- Verification that containers are staged in rows not more than two drums wide, with labels facing outward and 3 feet of space between rows.
- Verification that all containers are being tracked on the transportation and disposal log.
- Verification that the accumulation area is clean and free of debris.
- Verification that appropriate emergency response equipment is present, if required, for the waste being staged.

7.3.7 Waste Transportation

Each transportation vehicle and load of waste will be inspected before leaving the site, and the inspection will be documented in the logbook. The quantities of waste leaving the site should be recorded on a transportation and disposal log. A subcontractor licensed for commercial transportation will transport non-hazardous wastes. If the wastes are hazardous, then the transporter will have a USEPA ID number and will comply with transportation requirements outlined in 49 CFR 171-179 (DOT) and 40 CFR 263.11 and 263.31 (Hazardous Waste Transportation).

The transporter will observe the following practices when hauling and transporting wastes off site:

- Minimize impacts to general public traffic.
- Clean up waste spilled in transit.
- Line and cover trucks and trailers used for hauling contaminated waste to prevent releases and contamination.
- Decontaminate vehicles before reuse.

In accordance with the MOU, the Navy's radiological waste contractor will be responsible for transportation of the LLRW in accordance with the DOT Radioactive Material Transportation regulations of 49 CFR for off-site disposal. The Navy's radiological waste contractor may supply

DOT contamination surveys and radiation measurements on the outside of the container prior to shipment and will ensure that empty containers being returned to vendors meet the release limits for equipment and materials.

Off-site transportation and disposal of hazardous or solid wastes will be handled by the selected waste contractor. All hazardous waste transported from the site will be accompanied by a Uniform Hazardous Waste Manifest. Non-hazardous solid waste will be accompanied by a non-hazardous waste manifest or bill of lading, as appropriate. Navy personnel will be responsible for reviewing and signing all waste documentation, including waste profiles, manifests, and land disposal restriction notifications (manifest packages). Before signing the manifest, the designated Navy official will ensure that pre-transport requirements of packaging, labeling, marking, and placarding are met and in accordance with 40 CFR Parts 262.30–262.33, and 49 CFR Parts 100–178.

7.3.8 Waste Disposal

Hazardous and solid wastes will be transported off site for appropriate treatment and disposal. Hazardous waste will be disposed of or managed only at a hazardous waste disposal facility prequalified by EIP and the Navy and permitted for the disposal of the particular type of hazardous or solid waste generated.

7.4 Waste Minimization

To minimize the volume of hazardous and radioactive waste generated during the project, the following general guidelines will be followed:

- Waste material will not be contaminated unnecessarily.
- Work will be planned.
- Material may be stored in large containers, but the smallest reasonable container will be used to transport the material to its destination.
- Cleaning and extra sampling supplies will be maintained outside any potentially contaminated area to keep them free of contamination and to minimize additional waste generation.
- Mixing of detergents or decontamination solutions will be performed outside potentially contaminated areas.
- When decontaminating radioactively contaminated material, every effort will be made to minimize the generation of mixed waste.
- Contaminated material will not be placed with clean material.
- Wooden pallets inside the exclusion zone will be covered with plastic.
- Material and equipment will be decontaminated and reused when practicable.
- Volume reduction techniques will be used when practicable.

7.5 Compliance with CERCLA Offsite Rule

Consistent with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Offsite Rule, wastes generated from remediation activities, such as contaminated soil or hazardous waste, at a CERCLA site may be transferred only to off-site facilities that have been deemed acceptable by the USEPA Regional Offsite Contact (40 CFR 300.440). With Naval approval, the contractor will request proof of Offsite Rule approval from the off-site disposal facility before transferring any wastes to an off-site facility.

Other disposal practices to be followed are as follows:

- Hazardous waste (State and Resource Conservation and Recovery Act [RCRA]) will be sent to an off-site, permitted, RCRA Subtitle C treatment, storage, and disposal facility.
- Non-hazardous wastes will be disposed of at an off-site RCRA Subtitle D facility permitted to receive such wastes. Contaminated soil and debris are expected to be classified as non-hazardous and disposed of at a Subtitle D facility.
- Decontamination water may be discharged to an on-site water treatment facility with written permission from the Base or disposed at an off-site facility permitted to accept the waste.
- Uncontaminated debris may be sent to a municipal landfill, a landfill designated for construction/demolition debris, or a recycling facility.
- General trash will be placed in dumpsters on the Base.

Designated off-site facilities will be responsible for providing to the generator a copy of the fully executed waste manifest and a certificate of treatment or disposal for each load of waste received.

7.6 Documentation

Documentation requirements apply to all waste managed during project activities. Field records will be kept of all waste-generating activities. All pages of the field data record log will be signed and dated by the person entering the data. The following information also will be recorded in the log:

- Description of waste-generating activities
- Location of waste generation (including depth, if applicable)
- Type and volume of waste
- Date and time of generation
- Description of any waste sampling
- Name of person recording information
- Name of field manager at time of generation

7.7 Updating the Waste Management Plan

The Waste Management Plan section will be updated as changes in site activities or conditions occur, as changes in applicable regulations occur, and/or as replacement pages are added to this RSEWP. Revisions to waste management will be reviewed and approved by the Navy. All changes to the plan associated with radioactive or mixed waste will require approval from RASO.

8.0 ENVIRONMENTAL PROTECTION PLAN

This section briefly describes the environmental protection plan that will be implemented.

8.1 Land Resources and Vegetation

Parcel E is within a developed former industrial area with limited to no vegetation. The administrative provisions of the applicable permit programs will be applied to protect wetlands and streams, if appropriate.

8.2 Fish and Wildlife, Threatened, Endangered, and Sensitive Species

Several hundred types of plants and animals are believed to live at or near HPNS. No federally listed endangered or threatened species are known to permanently reside at HPNS or in the vicinity (Levine-Fricke and PRC, 1997); however, San Francisco Bay is a seasonal home to migrating fish and birds.

8.3 Wetlands and Streams

Two freshwater streams, Yosemite and Islais Creeks, flow into San Francisco Bay adjacent to the border with HPNS. Surface water resources at the site are limited to small groundwater seeps from exposed bedrock and the surface water in San Francisco Bay. The administrative provisions of the applicable permit programs will be applied to protect wetlands and streams, if appropriate.

8.4 Stormwater, Sediment, and Erosion Control

Stormwater, sediment, and erosion control will be managed through the Stormwater Plan (SWP), prepared under separate cover for the work outlined in Section 3, and the use of BMPs.

8.4.1 Stormwater Pollution Prevention

Stormwater pollution prevention, otherwise known as stormwater management, includes measures that can reduce potential stormwater pollution from industrial activity pollutant sources. Stormwater management includes the following BMPs:

- Pollution prevention team,
- Risk identification and assessment,
- Preventive maintenance,
- Good housekeeping,
- Site security,
- Spill prevention and response,
- Stormwater pollution prevention,
- Sediment and erosion prevention,
- Inspection and monitoring, and
- Personnel training.

These BMPs help to identify and eliminate conditions and practices that could cause stormwater pollution. The SWP describes the entire program to include the regulatory requirements and methods used to meet these requirements.

Inspections play a large role in the prevention of releases and pollution of stormwater. Qualified contractors and personnel perform inspections as described in the SWP. These inspections are documented and retained pursuant to the requirements of Section 6.

8.4.2 Stockpile Control

Stockpiles will be managed to ensure that any possible cross contamination with surrounding surfaces will be minimized to the extent possible. These measures will include, at a minimum, the following:

- All excavated material will be placed on plastic to prevent contact with the surface.
- All stockpiles will be covered with plastic or tarps at the end of the work shift or when stockpile additions or removals are complete and monitored on a weekly basis.
- BMPs (such as biodegradable wattles, fiber rolls, and erosion berms) will be used around stockpiles to prevent material migration.
- Stockpiling of known hazardous material will not be allowed. Hazardous material will be packaged as hazardous waste and stored under RCRA controls pending removal by a waste broker.

8.4.3 Non-radiological Hazardous Materials

Hazardous material will be managed in accordance with permits, plans, rules and laws. At a minimum, the following will be required:

- Hazardous material will be properly labeled and stored.
- Hazardous waste will be placed into approved containers and stored in designated Satellite Accumulation Areas or Waste Accumulation Areas.
- Hazardous material or waste containers will be kept closed when not in use.
- Before a worker opens any container/package with hazardous material, the project Environmental Manager will be consulted to determine whether pre-entry monitoring is required.

8.5 Air Quality and Dust Control

All intrusive activities will comply with the substantive requirements of the Bay Area Air Quality Management District Rule 40 and Regulations 6-305 and 8 pertaining to fugitive dust emissions and maintaining covering and stockpiling materials. Fugitive emissions will be minimized to the extent possible. Subsurface soil within the HPNS is expected to be moist and not require dust suppression. These measures will include, at a minimum, the following:

- Visible dust caused by intrusive methods will require work to be paused and the source of the dust corrected by dust suppression.
- Continuous radiological air samples (general area) will be collected during any intrusive work within areas of known or potential radiological contamination or material.
- Areas with known or suspected radiological material that could become airborne from light

winds (fine or powdered material) will be evaluated for a suitable stabilization method (dust control agent, fixatives, surfactants, or covering with erosion control covers).

- Area monitoring with direct reading dust monitors and photoionization detector.
- Stationary high-volume area sampling.

A site-specific Dust Control Plan (DCP) has been developed (**Appendix F**). Any air permits (e.g., local air quality board) that are required for the performance of work under this contract will be detailed in the project environmental plan.

8.5.1 Radiological Air Sampling

Airborne activity monitoring (continuous or grab samples) and engineering controls may be required during work when deemed appropriate by the License RSO, PRSO, contractor, or the Navy. Monitoring and trending for airborne radioactive material will be performed, as necessary, to control occupational exposures, establish PPE, and determine respiratory protection requirements. Engineered controls also will be implemented if required to maintain airborne concentrations below the applicable derived air concentration (DAC) value for the ROCs. DAC values for the ROCs are presented in **Table 8-1**.

During work, if the airborne concentration exceeds the appropriate DAC, ongoing activities will cease and the affected location will be posted until the source of the airborne concentration is eliminated and levels are confirmed to be below the appropriate DAC. Air monitoring will be performed using the methods described in SOP RP-107, *Measurement of Airborne Radioactivity* (**Appendix C**). Airborne contamination is not expected.

8.5.2 Non-radiological Area and Personal Air Monitoring

Air monitoring for non-radiological contaminants is expected during fieldwork at HPNS. In keeping with the philosophy of "Zero Dust," engineering controls will be the primary method to eliminate dust. To verify the effectiveness of the controls, the use of area direct-reading dust monitors (e.g., DataRAM) may be used. Area dust monitors may be deployed at select locations around the boundary of the site (environmental locations). In addition, stationary high-volume sampling will include upwind and downwind monitoring for the ROCs, total suspended particulates, lead, manganese, particulate matter larger than 10 microns in size, and asbestos.

Monitoring data will be compared with the threshold concentration levels developed for the project site. If an analyte concentration exceeds its threshold level, then the upwind and downwind results will be compared to identify whether the exceedance was caused by on-site activities. If on-site activities are found to be the cause of an exceedance, then the SSHO will immediately implement corrective actions to enhance the dust control measures being implemented. These measures include, but are not limited to, applying additional water and/or soil stabilizers, reducing driving speeds on unpaved roads, and modifying the equipment and approach used to perform the work activities.

Breathing zone action levels will be established for non-radiological contaminants (e.g., heavy metals and polychlorinated biphenyls) based on prior soil sampling at the site and the task (e.g., drilling and excavation) to be conducted. Direct-reading monitoring equipment (e.g., DataRAM and photoionization detector) will be used to verify action levels are not exceeded during work tasks.

Each project task plan will evaluate if non-radiological personal integrated air sampling is required, in addition to direct-reading monitoring. The SSHP will be updated via a Field Change Request if additional monitoring is needed based on task-specific chemicals of concern. The APP/SSHP further discusses personal air monitoring requirements of the project.

8.6 Noise Prevention

Using standard OSHA occupational noise evaluation methods, the time-weighted average for any 8-hour period will not exceed 90 decibels (dBA) to any worker. In addition, EIP will endeavor to limit noise directly resulting from project work to 80 dBA or less at the task area boundary, or 70 dBA at the HPNS boundary.

8.7 Construction Area Delineation

Construction area delineation will be evaluated upon arrival of the advance project personnel. Following this evaluation, minor modifications may be made to the project plans and procedures to reflect the current conditions.

8.8 Traffic Control Plan

A Traffic Control Plan (TCP) is provided in **Appendix D**.

8.9 General Operations

General operations will be governed under this RSEWP to ensure that any operation conforms to the requirements listed within. These requirements are specific to the type of hazard (e.g., radiological, hazardous material, and health and safety) and further require that each task have a corresponding AHA. All work will be released by the cognizant contractor before work is performed. Review of the general operations AHA will include all environmental programs and permits to ensure compliance.

8.10 Spill Prevention, Response, and Reporting

The project spill prevention and response plan is provided in the APP/SSHP.

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ED_006787_00009400-00099

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FIGURES

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Legend

- Parcel E
- Other Parcels
- Parcel F (Water) Boundary

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N

0 450 900 1,800 Feet

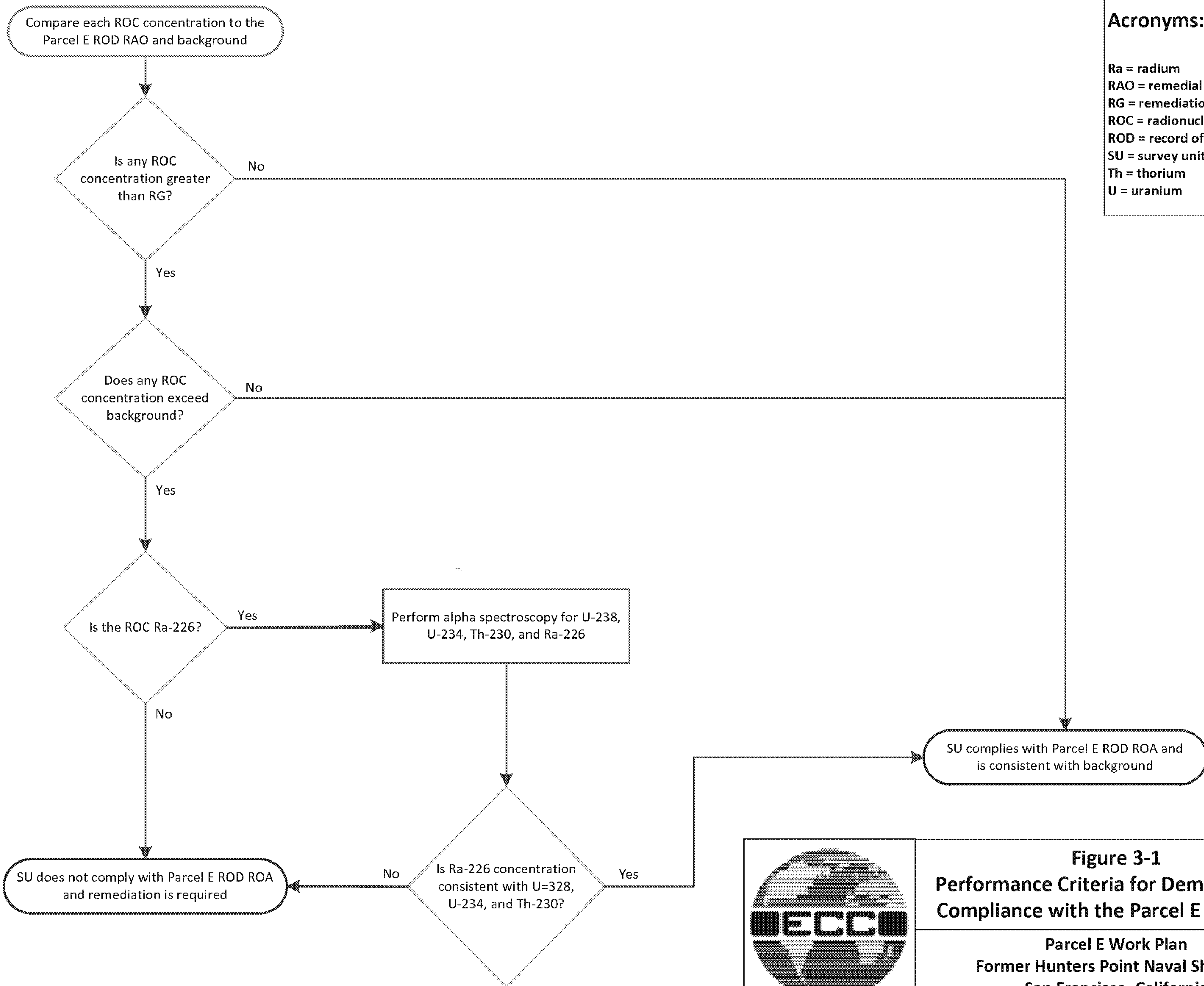
1 inch = 900 feet

Figure 1-1
HPNS and Parcel E Location

Parcel E Work Plan
Former Hunters Point Naval Shipyard
San Francisco, California

Figure 1-2
Soil and Building Sites

Parcel E Work Plan
Former Hunters Point Naval Shipyard
San Francisco, California



Acronyms:

Ra = radium
RAO = remedial action objective
RG = remediation goal
ROC = radionuclide of concern
ROD = record of decision
SU = survey unit
Th = thorium
U = uranium

Figure 3-1
Performance Criteria for Demonstrating Compliance with the Parcel E ROD - Soil

Parcel E Work Plan
Former Hunters Point Naval Shipyard
San Francisco, California

Legend

- Parcel E Boundary
- Existing Impacted Buildings
- Demolished Impacted Buildings
- Phase 1 Trench Units
- Phase 2 Trench Units

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N

0 150 300 600 Feet

1 inch = 300 feet

Figure 3-2
Phase 1 Trench Unit Locations

Parcel E Work Plan
Former Hunters Point Naval Shipyard
San Francisco, California

Figure 3-3
Phase 2 Trench Unit Locations

Parcel E Work Plan
Former Hunters Point Naval Shipyard
San Francisco, California

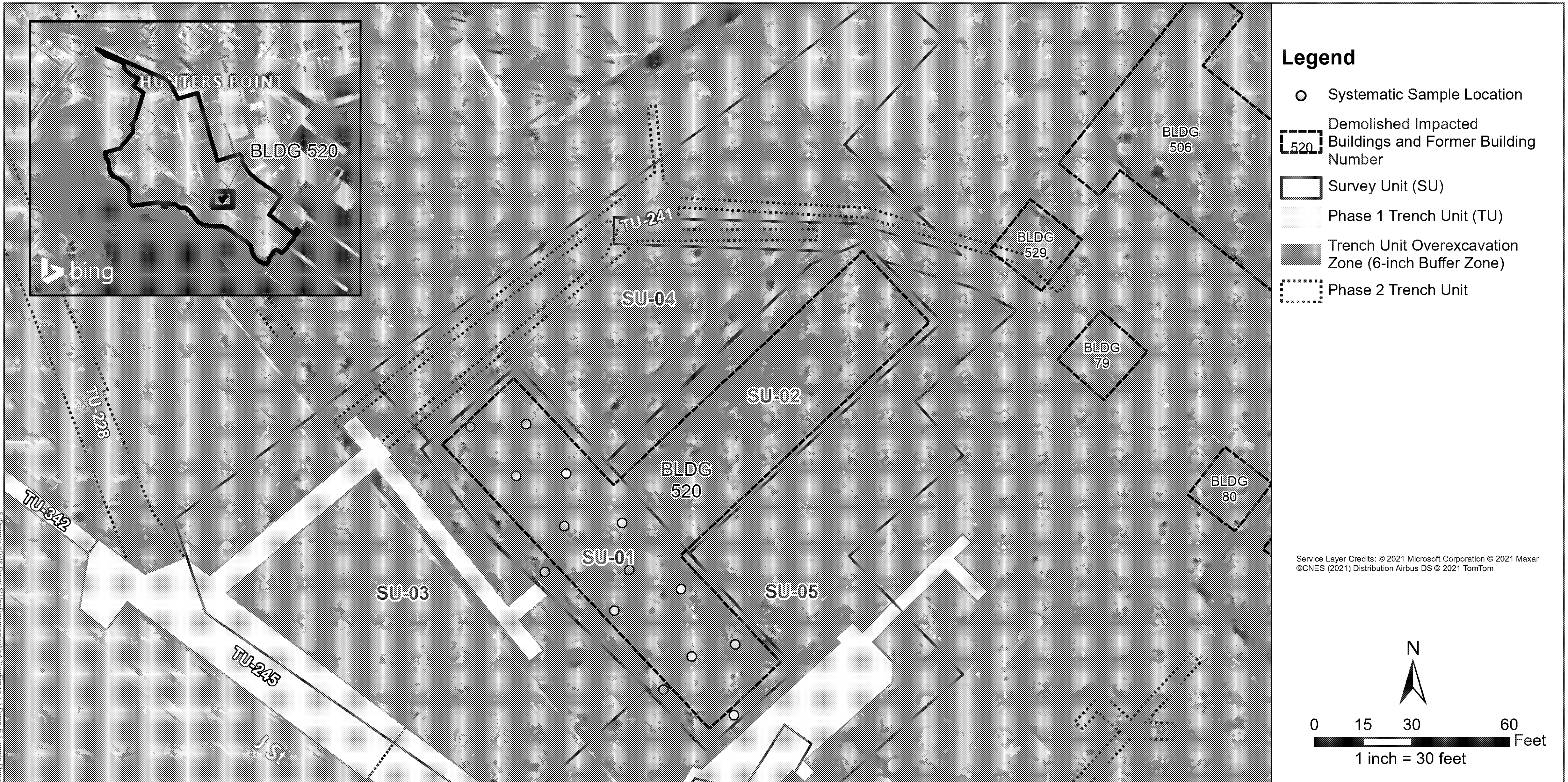
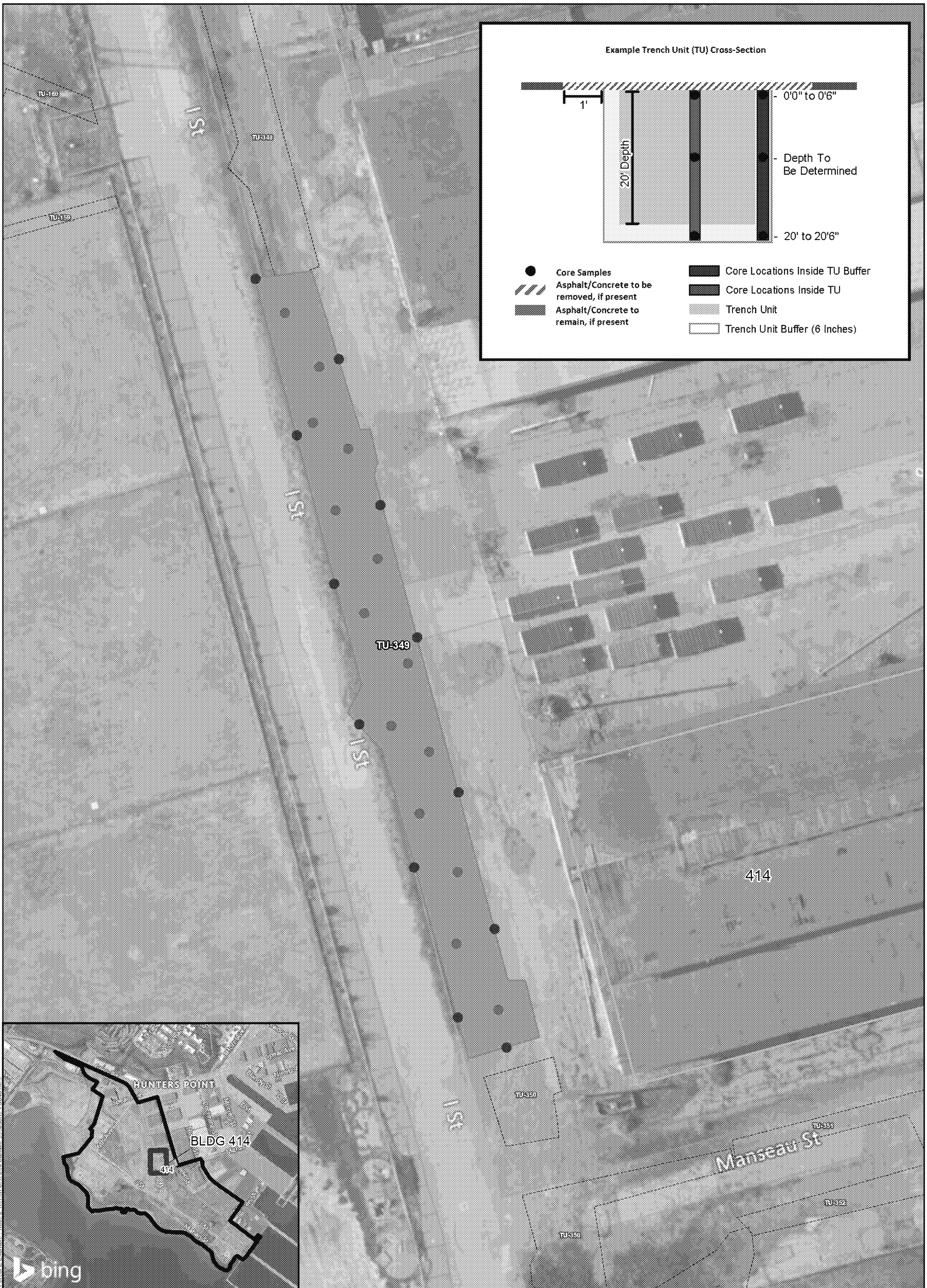


Figure 3-4
Example Phase 1 Trench Units and Survey Units

Parcel E Work Plan
Former Hunters Point Naval Shipyard
San Francisco, California



Legend

- Core Locations Inside Trench Unit (TU)
- Core Locations Inside TU Buffer
- TU-349
- TU-349 Buffer (6 inches)
- Trench Units
- Existing Impacted Buildings

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N

0 15 30 60 Feet

1 inch = 30 feet

Figure 3-5
Example Soil Sampling Locations for a Phase 2 Trench Unit

Parcel E Work Plan
Former Hunters Point Naval Shipyard
San Francisco, California

Legend

- Parcel E Boundary
- Existing Impacted Buildings
- Demolished Impacted Buildings

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N

0 150 300 600 Feet

1 inch = 300 feet

Figure 3-6
Former Building Sites
Soil Survey Unit Locations

Parcel E Work Plan
Former Hunters Point Naval Shipyard
San Francisco, California

Legend

- Proposed Soil Processing Area
- Stabilized Construction Entrance / Exit
- Construction Equipment Refueling Area
- Parcel E Boundary
- Existing Impacted Buildings
- Demolished Impacted Buildings
- Phase 1 Trench Units
- Phase 2 Trench Units

Note:
Locations of Site Support Features and Engineering Controls are subject to change and based on site conditions and professional judgement.

Service Layer Credits: Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013
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N

0 75 150 300 Feet

1 inch = 150 feet

Figure 3-7
Proposed Project Facilities

Parcel E Storm Water Management Plan
Former Hunters Point Naval Shipyard
San Francisco, California

Legend

- Parcel E Boundary
- Existing Impacted Buildings
- Demolished Impacted Buildings
- Background Reference Area

Service Layer Credits: Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013
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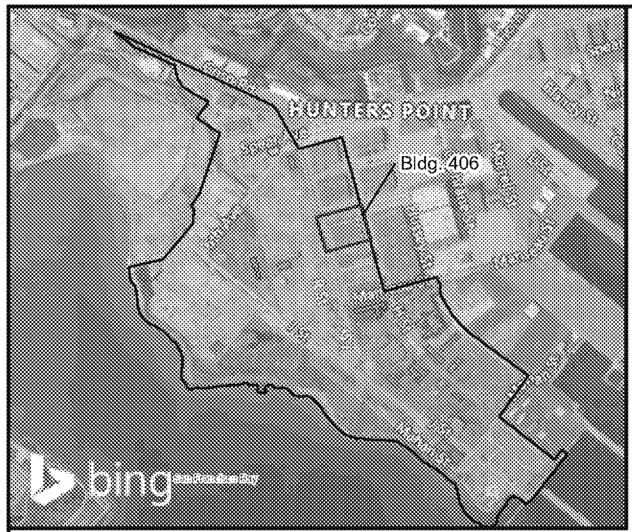
N

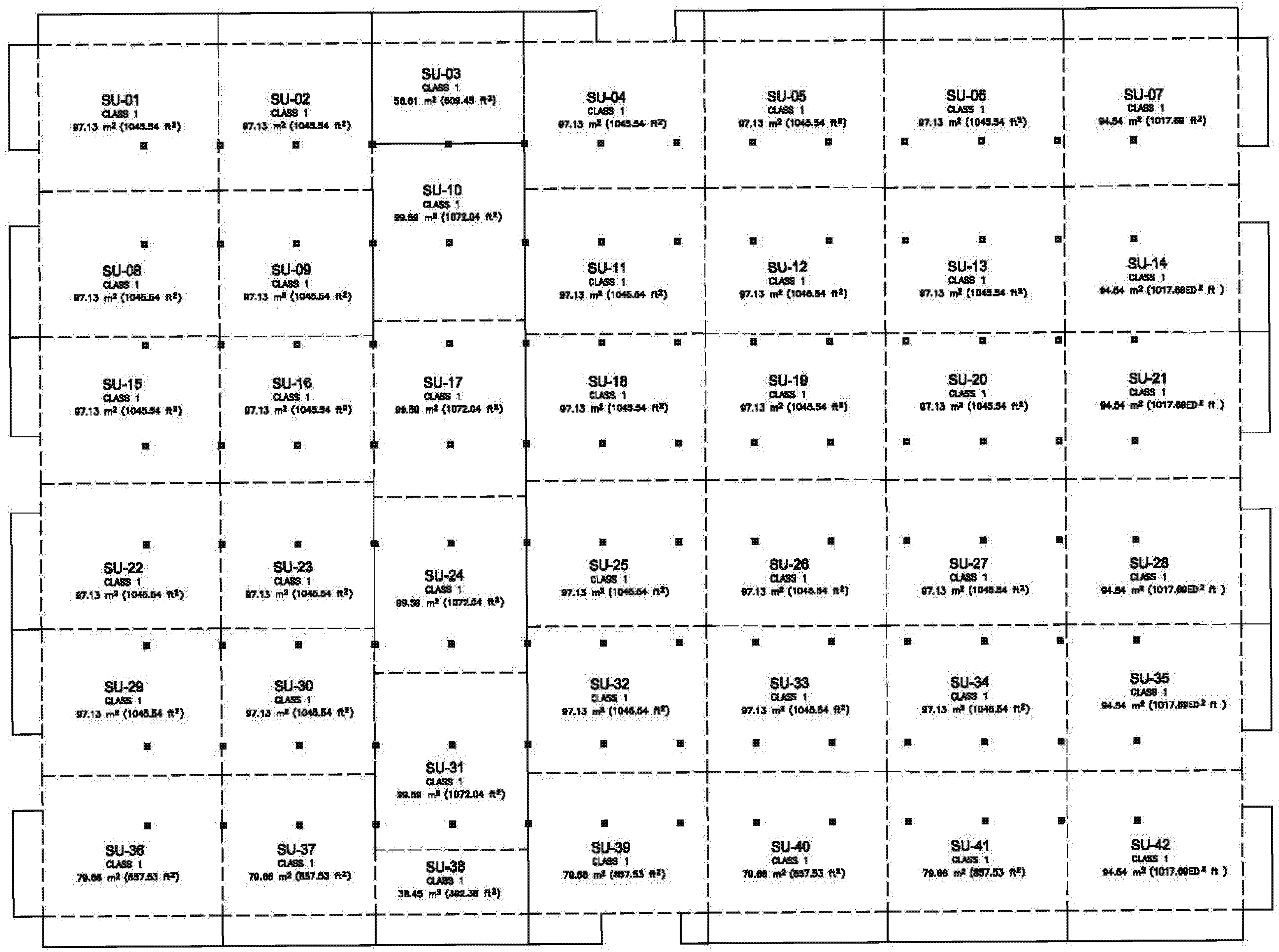
0 150 300 600 Feet

1 inch = 300 feet

Figure 4-1
Existing Impacted Building Locations

Parcel E Work Plan
Former Hunters Point Naval Shipyard
San Francisco, California





Legend

SU-01 Survey Unit Number

■ Column

- - - - - Survey Unit Boundary

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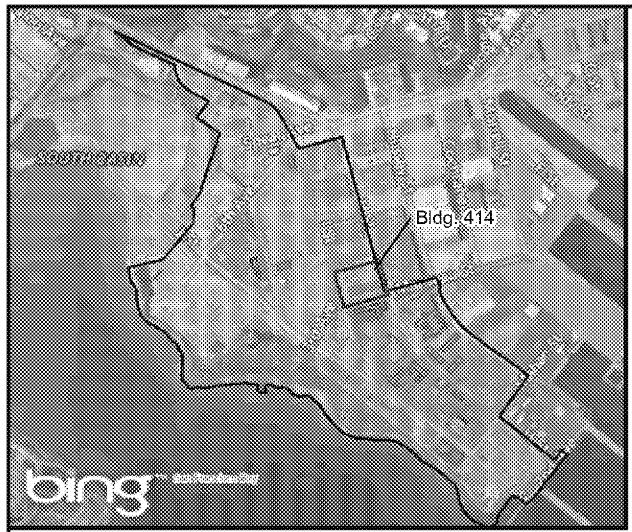
N

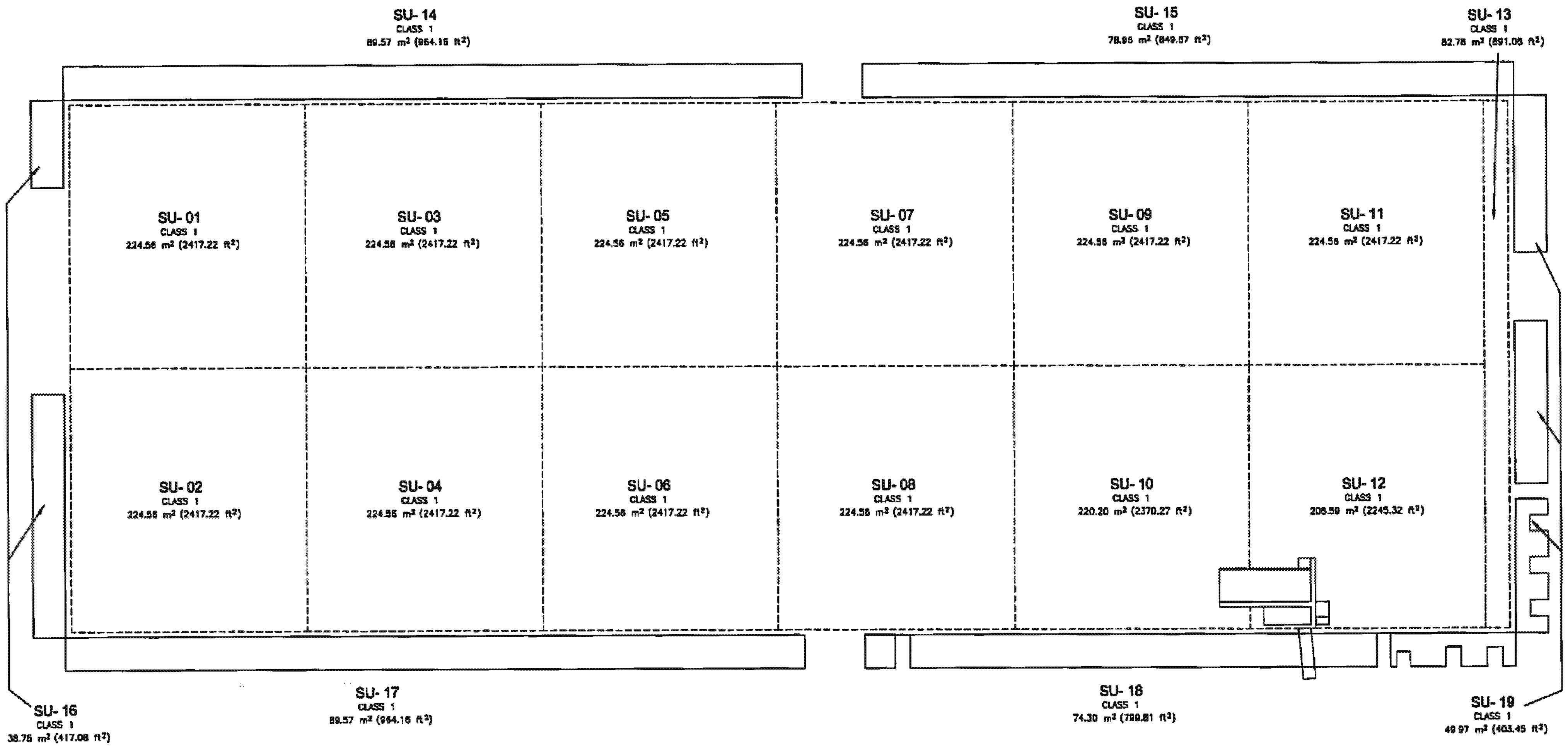
0 30 60 Feet

1 inch = 30 feet

Figure 4-2
Building 406 Floor Plan

Parcel E Work Plan
Former Hunters Point Naval Shipyard
San Francisco, California





Legend

SU-01 Survey Unit Number

- - - - - Survey Unit Boundary

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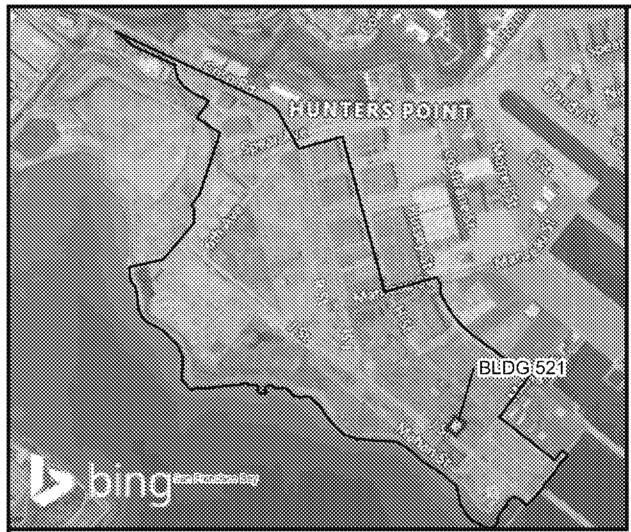
N

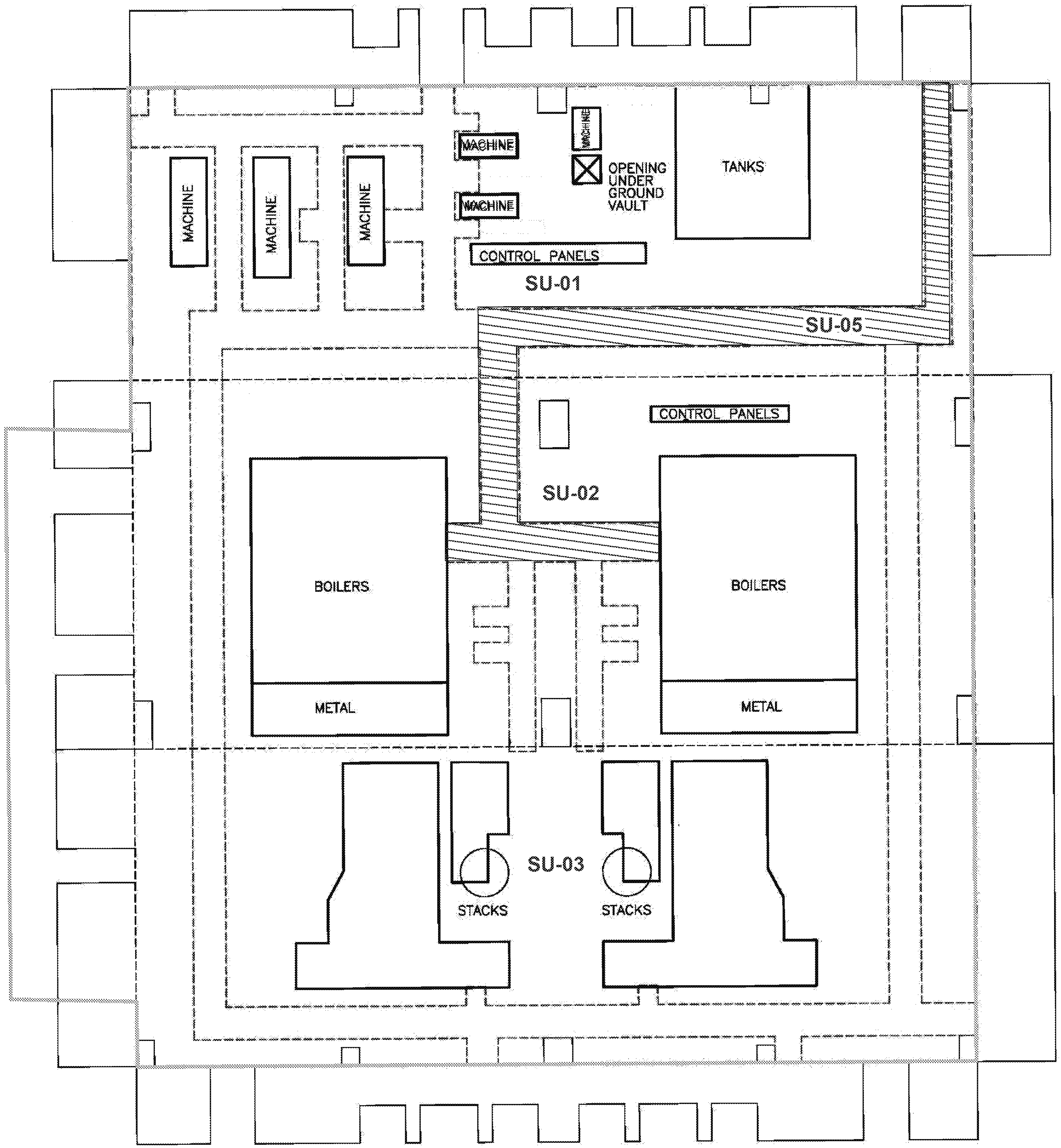
0 30 60 Feet

1 inch = 30 feet

Figure 4-3
Building 414 Floor Plan

Parcel E Work Plan
Former Hunters Point Naval Shipyard
San Francisco, California





Legend

Building 521

SU-01 Survey Unit Number

- - - - Survey Unit Boundary

BOTTOM OF TRENCH

SU-01
CLASS 1
86.40 m^2 (930.10 ft^2)

SU-02
CLASS 1
91.72 m^2 (987.36 ft^2)

SU-03
CLASS 1
98.46 m^2 (1059.83 ft^2)

SU-05
64.54 m^2 (694.78 ft^2)

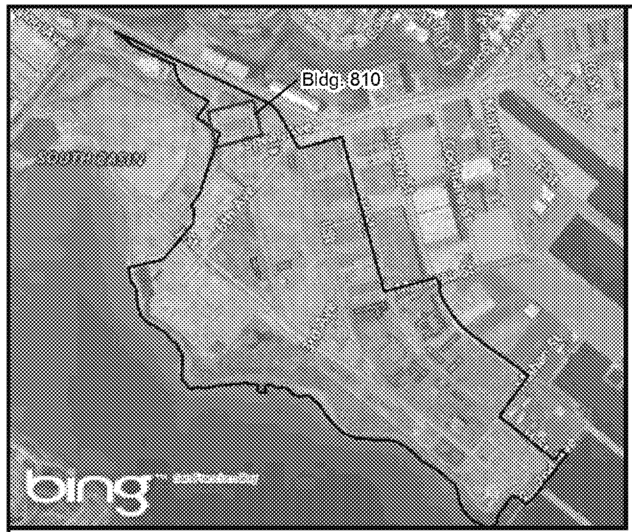
N

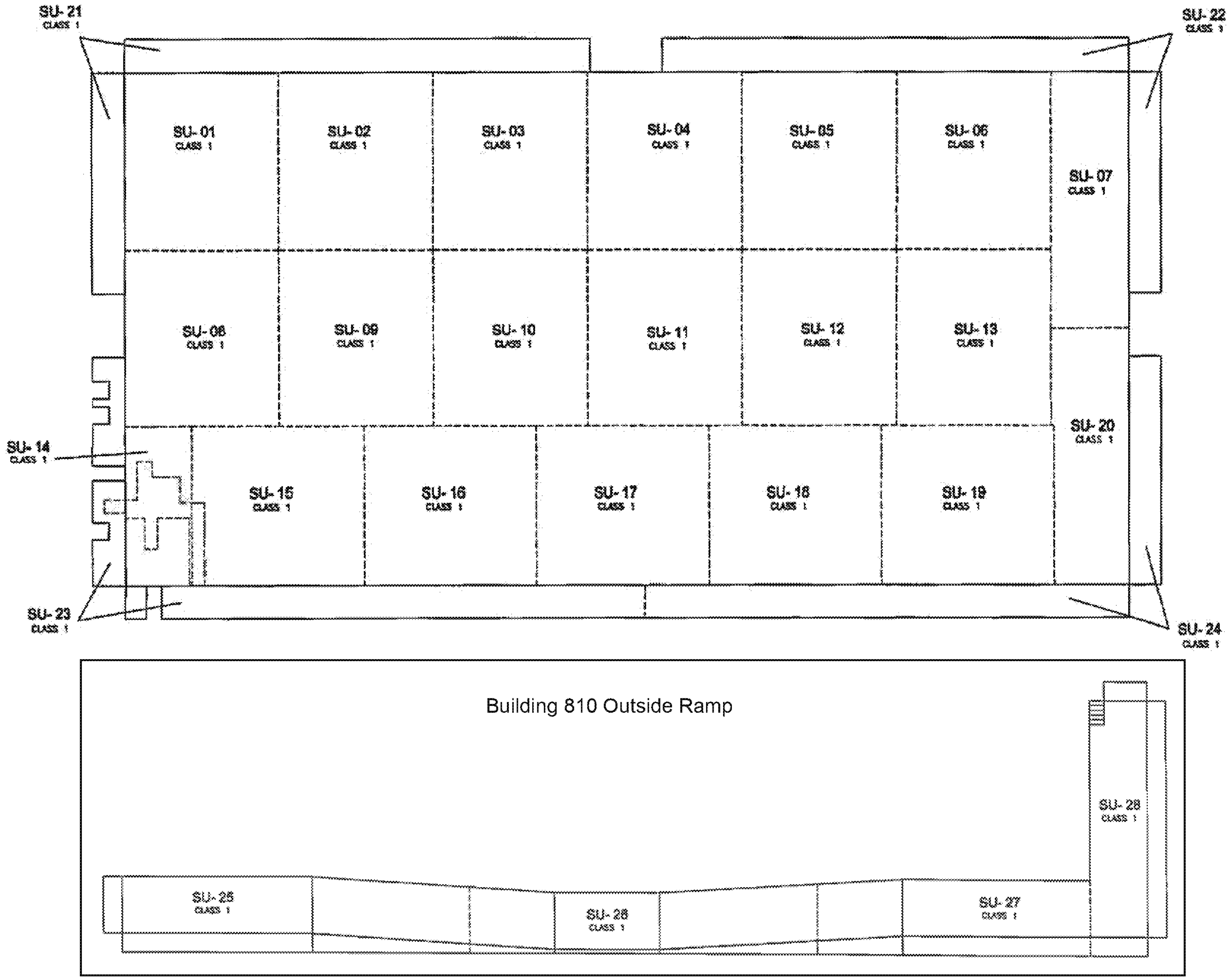
0 10 20 Feet

1 inch = 10 feet

Figure 4-4
Building 521 Floor Plan

Parcel E Work Plan
Former Hunters Point Naval Shipyard
San Francisco, California





Legend

SU-01 Survey Unit Number

- - - - - Survey Unit Boundary

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N

0 30 60 Feet

1 inch = 30 feet

Figure 4-5
Building 810 Floor Plan

Parcel E Work Plan
Former Hunters Point Naval Shipyard
San Francisco, California

Acronyms:

RAO = remedial action objective
RG = remediation goal
ROD = record of decision
SU = survey unit

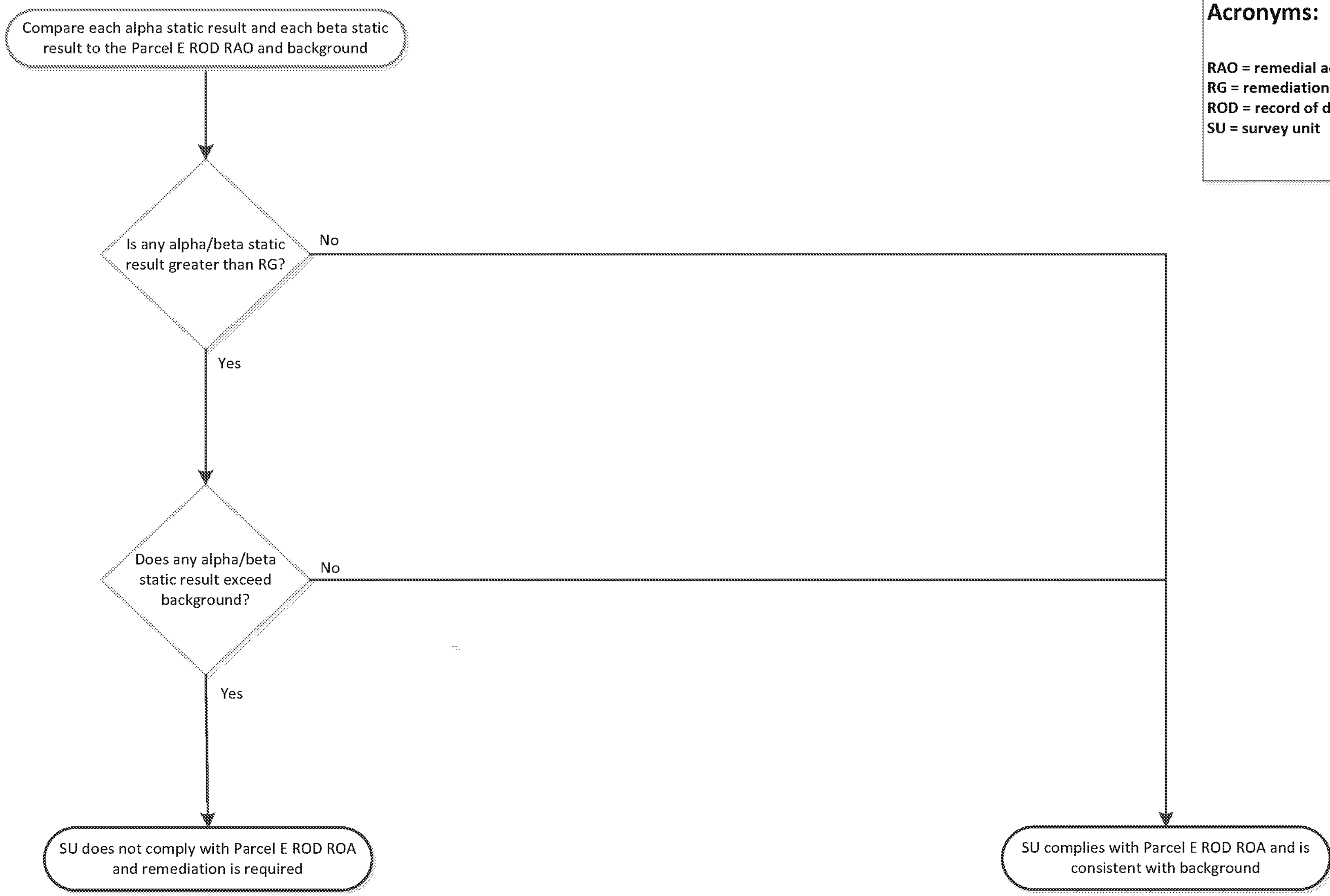
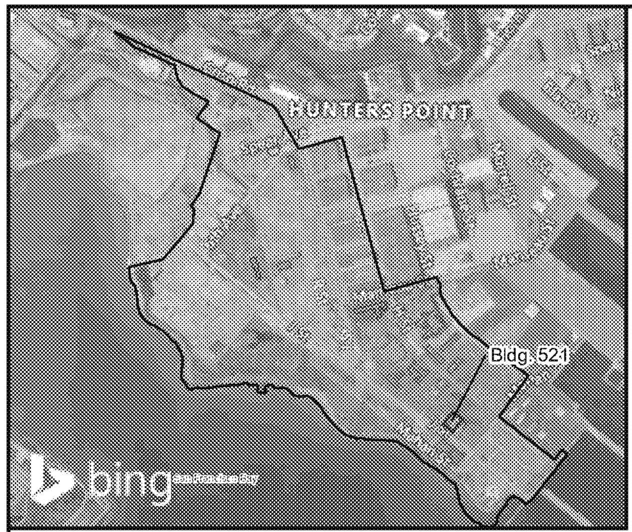
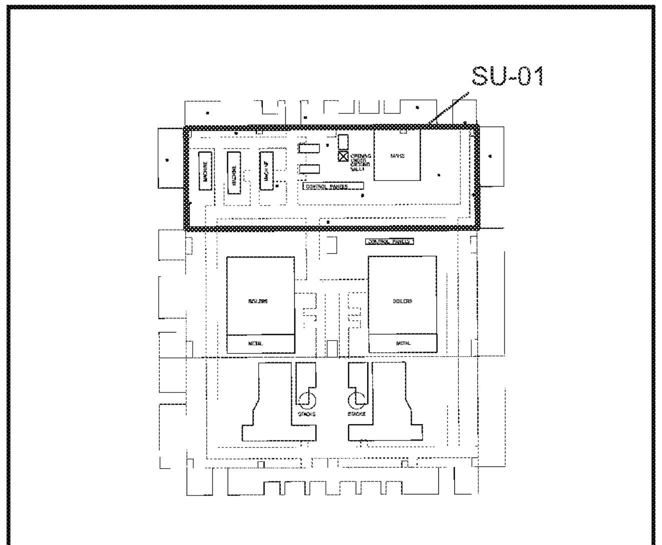


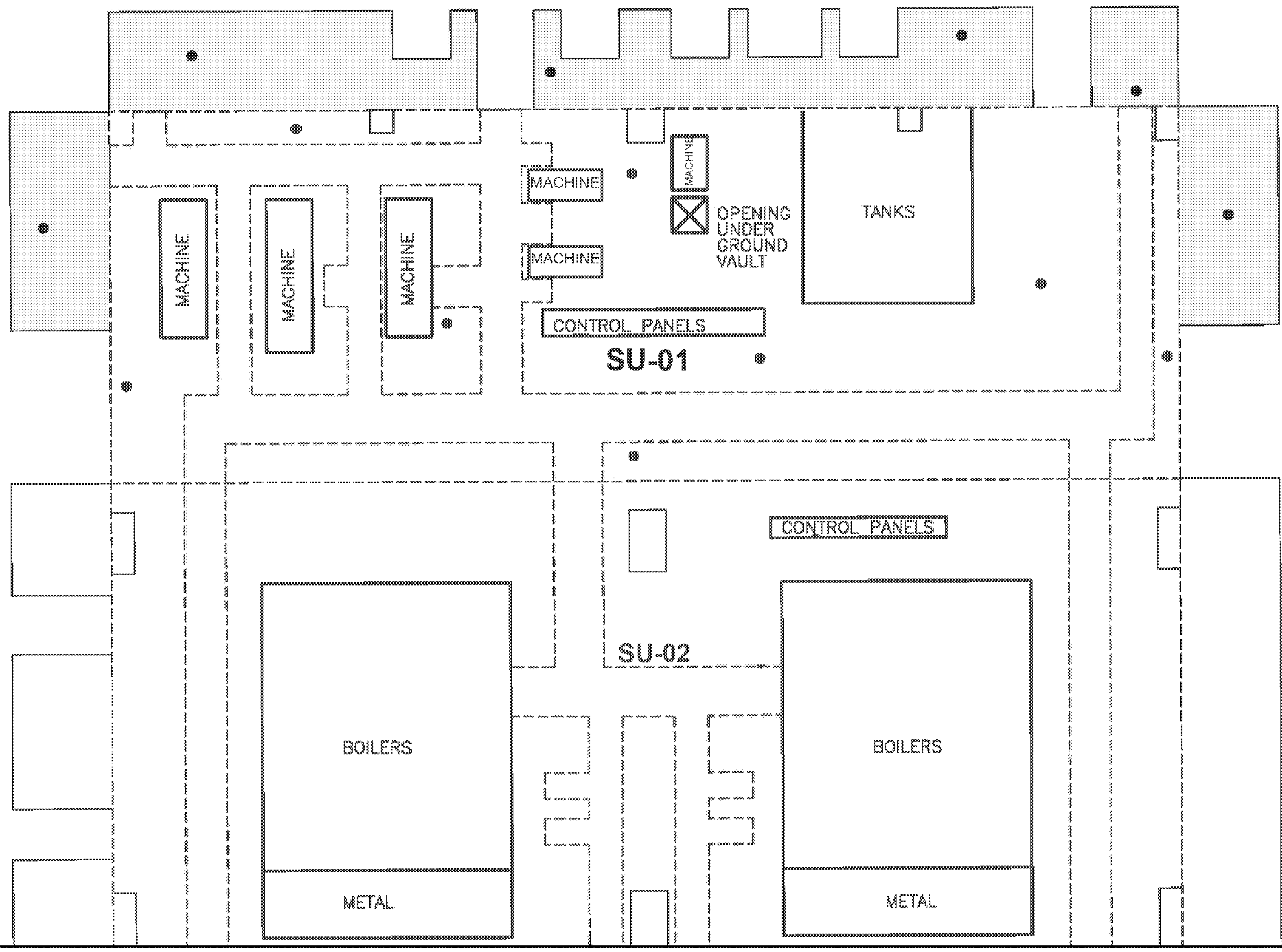
Figure 4-6
Performance Criteria for Demonstrating Compliance with the Parcel E ROD - Buildings

Parcel E Work Plan
Former Hunters Point Naval Shipyard
San Francisco, California





Building 521 Floor Plan



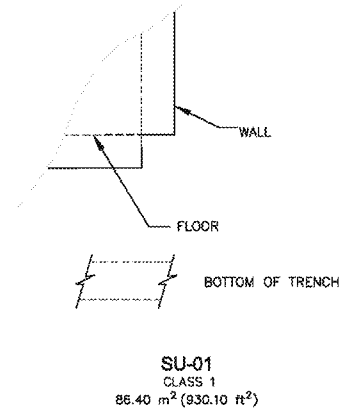
Legend

Floor (SU-01)

Lower Wall (SU-01)

SU-01 Survey Unit Number

● Systematic Static and Swipe Location



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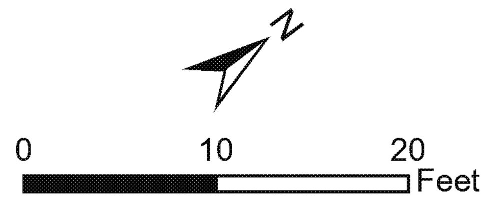
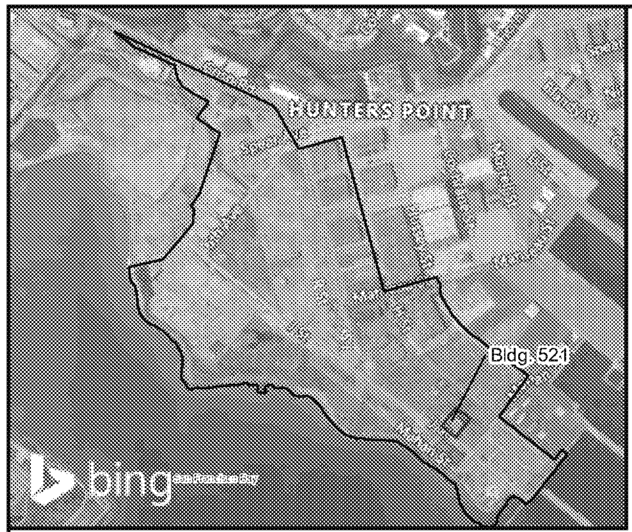
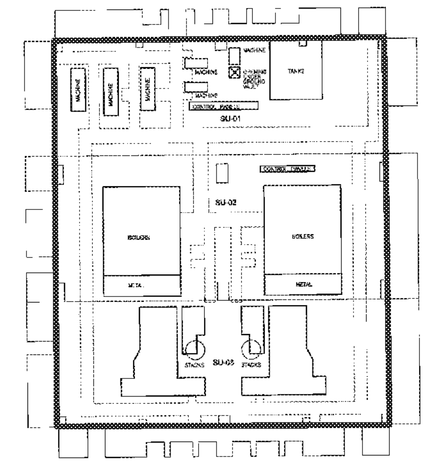


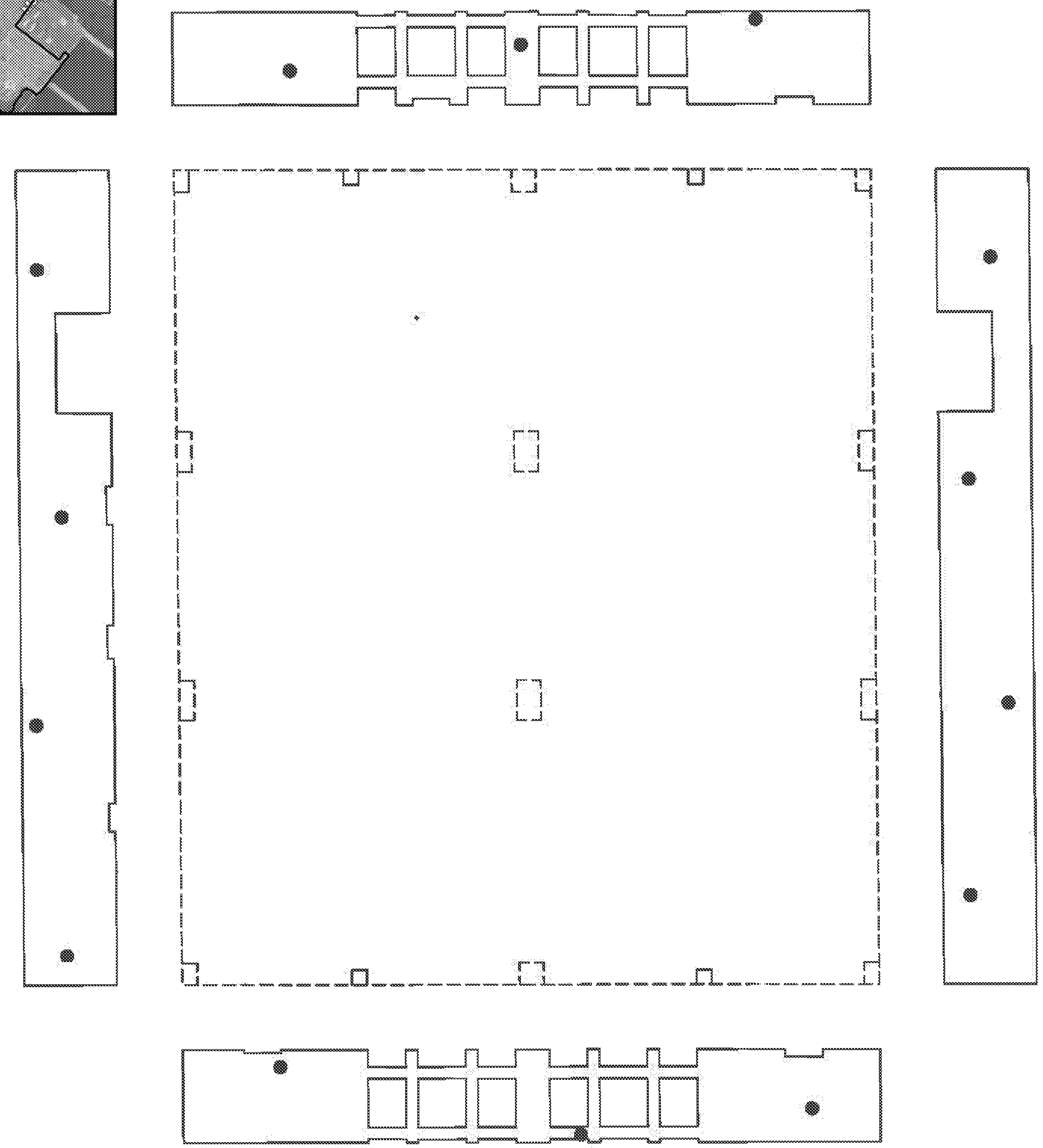
1 inch = 10 feet

Figure 4-7
Example Building Class 1 Survey Unit and Sample Locations

Parcel E Work Plan
Former Hunters Point Naval Shipyard
San Francisco, California







Building 521 Floor Plan

Legend

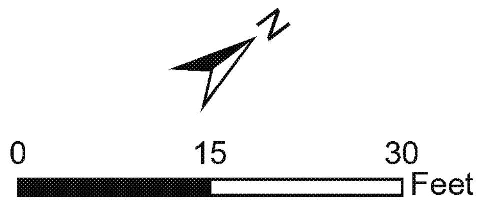
Ceiling

Upper Wall (SU-04)

SU-04 Survey Unit Number

● Systematic Static and Swipe Location

SU-04
CLASS 2
218.90 m^2 (2,356.30 ft^2)



1 inch = 15 feet

Figure 4-8
Example Building Class 2
Survey Unit and
Sample Locations

Parcel E Work Plan
Former Hunters Point Naval Shipyard
San Francisco, California

TABLES

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Table ES-1. Soil and Building Trench and Survey Units

Site	Soil	Building Surfaces	Soil		Building[a]		
			Building Site Soil Survey Units	Trench Units	Class 1 Survey Units	Class 2 Survey Units	Class 3 Survey Units
Storm Drain and Sanitary Sewer Lines	X			TU-152, TU-158, TU-159, TU-162, TU-163, TU-214, TU-217, TU-222, TU-223, TU-235, TU-245, TU-246, TU-300, TU-301, TU-307, TU-340, TU-341, TU-342, TU-345, TU-346 TU-154, TU-155, TU-156, TU-157, TU-160, TU-161, TU-165, TU-201, TU-215, TU-216, TU-218, TU-224, TU-225, TU-228, TU-229, TU-230, TU-241, TU-248, TU-249, TU-305, TU-306, TU-308, TU-309, TU-310, TU-311, TU-343, TU-344, TU-347, TU-348, TU-349, TU-350, TU-351, TU-352, TU-353, TU-354, TU-355			
Former Building Site 517	X		SU-1 and SU-2				
Former Building Site 503	X		SU-1, SU-2, SU-3, SU-4, SU-5, SU-6, SU-7, SU-8, SU-9, SU-10, SU-11, SU-12, SU-13, SU-14, SU-15, SU-16, SU-17, SU-18, SU-19, SU-20, SU-21, SU-22, SU-23, SU-24, SU-25, SU-26, SU-27, SU-28, SU-29, SU-30, SU-31, SU-32, SU-1, SU-33, SU-34, and SU-35				
Former Building Site 520	X		SU-1, SU-2, SU-3, SU-4 and SU-5				
Former Building Site 506	X		SU-1, SU-2, SU-3, SU-4 and SU-5				
Former Building Site 508	X		SU-1				
Former Building Site 510	X		SU-1				
Former Building Site 529	X		SU-1				
IR-04 Former Scrap Yard and Former Building 807 Site	X		SU-1, SU-2, SU-3, SU-4, SU-5, SU-6, SU-7, SU-8, SU-9 and SU-10				
Former Building Site 704	X		SU-1, SU-3 and SU-4				
Former Building Site 704 Storage Yard	X		SU-1, SU-3, SU-4, SU-6 and SU-7				
Former Building Site 707 Triangle	X		SU-1, SU-2, SU-3, SU-4, SU-5, SU-6, SU-7, SU-8, SU-9, SU-10, SU-11, SU-12, SU-13, SU-14, SU-15, SU-16, SU-17, SU-18, SU-19, SU-20, SU-21, SU-22 and SU-23				
Former Building Site 500 Series	X		SU-1, SU-2, SU-3, SU-4, SU-5, SU-6, SU-7, SU-8, SU-9, SU-10, SU-11, SU-12, SU-13, SU-14, SU-15, SU-16, SU-17, SU-18, SU-19, SU-20, SU-21, SU-22, SU-23, SU-24, SU-25, SU-26 and SU-27				
Former Building Site Shack 79 and 80	X		SU-1, SU-2 and SU-3				
Building 406		X			42	1	0
Building 414		X			19	1	0
Building 521		X			6	1	1
Building 810		X			28	1	0

Notes: [a] Building survey unit data is based on available documentation and may not reflect current site conditions. Updated survey unit data will be provided as part of the building surveys.

TU = Trench Unit
SU = Survey Unit

Table 1-1. Key Project Personnel

Agency	Contact	Project Title
NAVFAC SW 33000 Nixie Way, Building 50 San Diego, CA 92147	Paul Stoick 619.524.5755 paul.stoick@navy.mil	Navy Lead RPM
NAVFAC SW 33000 Nixie Way, Building 50 San Diego, CA 92147	Sean-Ryan McCray sean-ryan.mccray.ctr@navy.mil	Navy RPM
Officer in Charge Naval Sea System Detachment Radiological Affairs Support Office 160 Main Road Yorktown, VA 23691	NAVSEADET RASO 757.887.4692 navsearasoadmin.fct@navy.mil	Navy Radiological Environmental Protection Manager
NAVFAC SW ROICC San Francisco Bay Area 950 W. Mall Square, Building 1, Suite 160 MS2 Alameda, CA 94501	Shirley Ng 510.501.1170 shirley.ng@navy,mil	ROICC Project Engineer
NAVFAC SW 1220 Pacific Highway San Diego, CA 92132	Joseph Arlauskas 619.532.4953 joseph.arlauskas@navy.mil	Quality Assurance Officer
NAVFAC SW CSO Hunters Point Naval Shipyard One Avenue of the Palms, Suite 161 San Francisco, CA 94130	Doug DeLong 415.743.4713 (office) 510.220.1894 (mobile) douglas.delong.ctr@navy.mil	CSO
U.S. Environmental Protection Agency, Region 9 75 Hawthorne Street (SFD-8-3) San Francisco, CA 94105	Karen Ueno 415.972.3317 ueno.karen@epa.gov	EPA RPM
California Department of Toxic Substances Control 700 Heinz Ave. Berkeley, CA 94710	Nina Bacey 510.540.2480 juanita.bacey@dtsc.ca.gov	Cal/EPA DTSC RPM
California Department of Public Health Environmental Management Branch, MS 7402 1616 Capitol Ave Sacramento, CA 95899	Sheetal Singh 916.449.5691 sheetal.singh@cdph.ca.gov	CDPH RPM
California Regional Water Quality Control Board San Francisco Bay Region 1515 Clay Street, Suite 1400 Oakland, CA 94612	Tina Low 510.622.5682 tina.low@waterboards.ca.gov	RWQCB RPM
City and County of San Francisco Department of Public Health 1390 Market St., Suite 210 San Francisco, CA 94102	Amy Brownell 415.252.3967 amy.brownell@sfdph.org	San Francisco DPH RPM
EIP, LLC 1240 Bayshore Hwy Burlingame, CA 94010	Matthew Long, 303.298.7607 (office) 774.244.7102 (mobile) mlong@ecc.net	Senior Project Manager
EIP, LLC 1240 Bayshore Hwy Burlingame, CA 94010	Joe Erdie jerdie@ecc.net	Construction Manager

Table 1-1 (continued). Key Project Personnel

Agency	Contact	Project Title
EIP, LLC 1240 Bayshore Hwy Burlingame, CA 94010	Richard Gioscia rgioscia@ecc.net	Program QC Manager
EIP, LLC 1240 Bayshore Hwy Burlingame, CA 94010	Dave Marks dmarks@ieeci.com	PQCM/Field Geologist
EIP, LLC 1240 Bayshore Hwy Burlingame, CA 94010	Alejandro Lopez alopez@perma-fix.com	Radiological Operations Manager
EIP, LLC 1240 Bayshore Hwy Burlingame, CA 94010	Keith Anderson kanderson@ecc.net	Project Health Physicist
EIP, LLC 1240 Bayshore Hwy Burlingame, CA 94010	Alejandro Lopez Perma-Fix alopez@perma-fix.com	Project Radiation Safety Officer/License Authorized User
EIP, LLC 1240 Bayshore Hwy Burlingame, CA 94010	Jackson Kiker jkiker@ecc.net	Program Chemist
EIP, LLC 1240 Bayshore Hwy Burlingame, CA 94010	James Cirillo 714.678.6700 (office) 949.231.0933 (mobile) JCirillo@ieeci.com	Project Chemist
EIP, LLC 1240 Bayshore Hwy Burlingame, CA 94010	Theodore Johnson 303.472.8834 (mobile) tjohnson@ecc.net	SSHO/CIH

Notes: CIH = Certified Industrial Hygienist
Cal/EPA = California Environmental Protection Agency
CSO = Caretaker Site Office
DPH = Department of Public Health
DTSC = California Department of Toxic Substances Control
EPA = United States Environmental Protection Agency
NAVFAC SW = Naval Facilities Engineering Command, Southwest
PQCM = Project Quality Control Manager
QC = quality control
ROICC = Resident Officer in Charge of Construction
RPM = Remedial Project Manager
RWQCB = California Regional Water Quality Control Board, San Francisco Bay Region
SSHO = Site Safety and Health Officer

Table 2-1. Conceptual Site Model

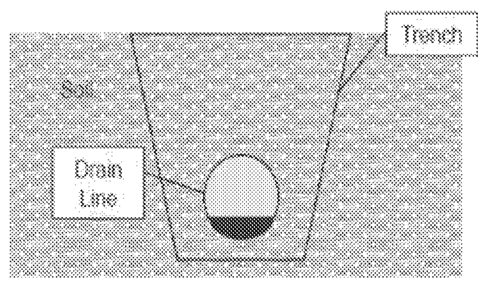
Site Name		Former Hunters Point Naval Shipyard (Parcel E)
Site Location		Located on San Francisco Bay near the southeastern boundary of San Francisco, California. Hunters Point Naval Shipyard (HPNS) encompasses approximately 848 acres, including approximately 416 acres on land, at the point of a high, rocky, 2-mile-long peninsula projecting southeastward into San Francisco Bay. Parcel E occupies approximately 128 acres of shoreline and lowland coast along the southwestern portion of HPNS (**Figure 1-1**).
Site Operations and History		• Navy Radiological Defense Laboratory (NRDL activities associated with analyzing samples from nuclear weapons tests, scientific studies (fallout, plant, animal, materials), and production and use of calibration sources. • The Historical Radiological Assessment (HRA) documents in Table 5-1 that the Navy had five radioactive licenses with the Atomic Energy Commission for ^{137}Cs, one for a quantity of 3,000 curies and a separate quantity of 20 curies of ^{137}Cs. Two licenses indicate that ^{137}Cs was in sources. In some cases, the Navy made its own sources with ^{137}Cs. • Use of radiography sources. • Use and potential disposal of radiological commodities, including discrete devices removed from ships (deck markers, radium dials) and welding rods. • Historical radiological material use documented in the HRA (NAVSEA, 2004) lists "impacted sites" – sites with potential for radioactive contamination. • Former surface soil impacted by fallout may be subsurface soil today because of fill activities.
Historical Site Conditions		Facility created from fill with some background levels of radionuclides (e.g., NORM and fallout). Dredge spoils from local berths were used as fill for some areas. Trenches were backfilled following removal of sewer lines. Trench backfill is mixed, but documentation of source is available (on-site fill, off-site fill, or mixture). Bay mud or bedrock marks bottom extent of fill material. Site drainage system was designed in the 1940s to discharge to San Francisco Bay and was separated into sanitary sewers and storm drains in 1958, 1973, and 1976, but never completed.

Potential Source Areas	**Potential Historical Sources of Radiological Contamination**	• Potential spills and releases from the following:
		  – Storage of samples from nuclear weapons tests at various NRDL facilities
		  – NRDL waste disposal operations:
		    ▪ Building 707 Triangle Area was used as NRDL waste receiving, packaging, and storage area
		    ▪ Animal research at Building 707
		• Incidental disposal of radioluminescent commodities (e.g., dials, deck markers) during maintenance, individually or attached to equipment.
		• Leaking radiography and calibration sources could affect buildings listed in HRA Table 6-1 related to production and maintenance of calibration sources.
		• Small amounts of low-level radioactive liquid waste were authorized for release with dilution to sanitary sewers based on regulations in place at the time.

	Release Areas in Parcel E	**Known Release Areas (from Section 6.4 of the HRA):**
		• Building 707 and Building 707 Triangle Area
		  – Contaminated drainpipe in Building 707
		  – Contamination under concrete pad at Building 707 was remediated
		Potential Releases Identified after the HRA:
		• Unknown

	Impacted Buildings in Parcel E	**Impacted Buildings with High Contamination Potential (from Table 8-2 of HRA):** • Building 529 (demolished) – Measured 17 feet by 29.5 feet and included an underground isotope storage vault and waste sump. Building 529 was used as NRDL Isotope Storage Facility (Vault) and Neutron Generator. When the building was renovated for installation of the neutron generator, the vault was filled with compacted sand and capped with 8 inches of concrete. • Building 707 and Kennels – Building 707 is irregular in construction and measures approximately 13,000 square feet, including kennels. Building 707 was used as a research animal facility used by NRDL for animal breeding and housing, Waste Processing and Storage Facility, formerly leased as an animal clinic • Building 707 Triangle Area – This site is triangular in shape and measures approximately 223,000 square feet. This location is bounded by "J" Street, "I" Street, and 6th Avenue. The site was formerly used as NRDL radioactive waste receiving, packaging, and storage area and suspected septic tank and leach field from early operations. **Impacted Buildings with Moderate Contamination Potential (from Table 8-2 of HRA):** • Building 406 – Building 406 is a common wood-framed, flush weather-boarded warehouse and shop-type building from WW II. The building is approximately 40,000 square feet and includes a central light and ventilation monitor joined by shallow shed roofs at either side. Building 406 was previously used as shipping, packing, and preserving and leased to an auto bodywork and towing company. • Building 500 Series – Consisting of demolished buildings and open space, the area of HPS where the 500 series buildings were located and is the location of the original RADLAB/NRDL facilities. In addition to the 500-series buildings, temporary structures were constructed, used, and removed, and radioactive materials were transported and stored outdoors. There were drain lines in buildings in the area, a dust collection system was constructed outside Building 506 for use by NRDL. Buildings 506, 507, 508, 510, 517, 520, and 701 were vacated in 1955 when NRDL moved to Building 815. • Building 506 (demolished) – Irregular in construction and measured 9,375 square feet at the foundation. Building 506 was previously used to store radioactive waste containers stored on pad behind the building, NRDL biology and health physics laboratories, animal, nuclear and physical chemistry laboratories, NRDL chemistry laboratories, radiochemistry laboratory, NRDL instrument repair, darkroom, and densitometer for film badges, counting rooms, electro-physical and surface chemistry laboratories, administrative offices, storerooms, duty watch berthing, personnel decontamination, and RADLAB/NRDL headquarters and main facility prior to move to Building 815 in 1955. • Building 507 (demolished) – The original building measured approximately 35 feet by 190 feet and appears to have been constructed as a wooden-framed, corrugated building. Building 507 was used as the NRDL biology laboratories, NRDL change house and animal quarters, radiological decontamination center, biochemistry branch, physiology-psychology branch, and experimental pathology branch. • Building 508 (demolished) – The original Building 508 measured approximately 35 feet by 190 feet. Building 508 was used as the NRDL chemistry branch, library, personnel branch, photographic section of publications branch, radiological safety branch, barracks, health services division, chemical technology and nucleonics divisions, security division, health physics division, employee relations branch, and pathology laboratory. • Building 510 (demolished) – The original building measured approximately 30 feet by 85 feet. Building 510 was used as weapons test sample storage, non-NRDL training facility, NRDL radiation facility, glassblowing, woodworking and machine shops, physics branch, nuclear radiation branch, and research engineering section physics branch. • Building 517 (demolished) – The original building measured approximately 50 feet by 50 feet. Building 517 was used as the former brig and NRDL cobalt animal irradiation facility. • Building 520 (demolished) – The original building was irregular in construction and measured approximately 7,040 square feet at its foundation. Building 520 was used as the shipyard dental clinic and NRDL administrative offices. • Building 704 – Building 704 is a metal-sheathed shop building with a radioactive material storage area south of the building and adjacent to the animal pens/kennels. • Building 810 – Wood-framed structure, sided in flush weatherboard and includes a flat roof with shallow shed-roofed elements on all sides. The monitor includes vents but no windows. Building 810 was formerly used as LLRW and IDW storage location, storehouse, paint shop, and paint and oil storage. • Shack 79 (demolished) – The type of construction is unknown but thought to be wood. Dimensions were not available, and the shack was located behind Building 506. Shack 79 was formerly used for NRDL support for radioactive material. • Shack 80 (demolished) – The type of construction is unknown but thought to be wood. The shack was located behind Building 506. Shack 80 was formerly used for NRDL Support and was reported to have been moved from behind Building 506 to Building 704 area for "lab operations".

Site Name	Former Hunters Point Naval Shipyard (Parcel E)
	Impacted Buildings with Low or No Contamination Potential (from Table 8-2 of HRA): • Building 414 – Wood-framed, corrugated metal-sided, 172-by-243-foot structure in the southern shipyard area that includes a tall, gabled main shop area with a shed-roofed extension to one side. Building 414 was formerly used as LLRW storage area for RI IDW, public works/supply storehouse, and Shaw Environmental & Infrastructure, Inc. site offices. • Building 521 – Building 521 is constructed of concrete and measures approximately 7,040 square feet at its foundation. Building 521 was used as a power plant and is one of two suspected sites of fuel oil burning from three OPERATION CROSSROADS target ships. • Building 701 (demolished) – The original building measured approximately 50 feet by 110 feet. Building 701 was used as a storage building that NRDL requested for "temporary" (120 days) storage of samples in 1947, however, the building was still in use by NRDL in 1954. • Building 704/Pens – Two former animal pens were identified on a 1949 map adjacent to the radioactive material storage area south of Building 704. The animal pens measured approximately 18 feet by 20 feet and 20 feet by 12 feet and have been removed. • Building 707 B (demolished) – This building is thought to have been of the same type as Building 708 (707A), a 50–by-20-foot Quonset hut. Building 707 B was used as the NRDL animal colony. • Building 707 C (demolished) – This building is thought to have been of the same type as Building 708 (707A), a 50-by-20-foot Quonset hut. Building 707 C was used as nuclear weapons test support and experimentation and equipment issue and receiving area. • Building 708 – Quonset hut adjacent to Building 707. It measures approximately 50 feet by 20 feet. Building 708 was formerly used as research animal facility, bio-medical facility, and animal psychology facility. • Building 807 (demolished) – This building measured approximately 60 feet by 28 feet. Building 807 was formerly used as scrap yard processing shed and possibly received scrap materials from ship decontamination.
Radionuclides of Concern for Parcel E (from Table 8-2 of HRA) 3	• ^{226}Ra • ^{137}Cs • ^{90}Sr (for soil, former building sites, and interior surfaces of Buildings 521 and 810) • ^{3}H (only for former Building 506 site) • ^{239}Pu (only for interior surfaces of Building 521 and the sites of former Buildings 506, 510/510A, 704, 704 Storage Yard, 707 Triangle, and the 500 Series) • ^{60}Co (only for former Building 517 site) • ^{241}Am (only for former Buildings 506 and the 500 Series) • ^{235}U (only for former Building 707 Triangle site) • ^{239}Pu (only for interior surfaces of Building 521 and former Buildings 364 and 365)

Potential Migration Pathways	• Releases to soil and air.
	• Releases to sanitary sewer lines.
	  – Buildings with known releases
	• Releases to storm drains.
	  – Incomplete separation from sanitary sewer lines
	• Runoff from surface spills.
	• Releases from potentially leaking storm drain and sanitary sewer lines to surrounding soil (now removed).
	• Release of sediments from breaks or seams during power washing of drain lines.
	
	
	Conceptual Cross Section of Drain Lines

Potential Exposure Pathways	• Soil:
	  – External radiation from radionuclides of concern (ROCs)
	  – Incidental ingestion and inhalation of soil and dust with ROCs for intrusive activities disturbing soil beneath the durable cover (only construction worker receptor)
	• Building surfaces:
	  – External radiation from ROCs
	  – Inhalation and incidental ingestion of resuspended radionuclides

Current Status	• HPNS is not an active military installation. In 1991, HPNS was selected for closure pursuant to the terms of the Defense BRAC Act of 1990. For more than 20 years, the Navy leased many HPNS buildings to private tenants and Navy-related entities for industrial and artistic uses. Current leases include art studios and a police department facility. Parcels A, D-2, UC-1, and UC-2 have been transferred to the City and County of San Francisco for nondefense use, and the remaining areas of HPNS are also planned to be transferred.
	• All known sources removed by Navy using standards at the time.
	  – Follow-up investigations resulted in removal of small volumes of soil to meet current remediation goals (RGs).
	• Sanitary sewer and storm drain removal investigation conducted at Parcel E from 2010 to 2016.
	  – More than 9,400 feet of trench lines and 18,000 cubic yards of soil investigated and disposed of or cleared for use as on-site fill
	  – Trench excavations that have been backfilled now contain homogenized soil from on-site fill, off-site fill, or a mixture of both

Uncertainties	• Lower potential for radiological contamination than originally described in historical CSMs based on the following lines of evidence:
	  – Known sources have been removed.
	  – Sanitary sewers and storm drains, and 1 foot of soil surrounding the pipe removed to the extent practicable. The sewer lines were removed to within 10 feet of all buildings. Impacted buildings had remaining lines removed during surveys of the buildings. Non-impacted buildings had surveys performed at ends of pipes, and pipes were capped.
	  – Any residual concentrations may be modified by radiological decay (shorter-lived radionuclides, such as ^{137}Cs and ^{90}Sr) or remobilization (including weathering and migration).
	  – Overestimate of ^{226}Ra concentrations in soil by the onsite laboratory using an imprecise measurement method.
	• Data manipulation or falsification.
	• Data quality deficiencies.
	• ^{137}Cs and ^{90}Sr are present at HPNS because of global fallout from nuclear testing or accidents, in addition to being potentially present as a result of Navy activities. Because of backfill activities, ^{137}Cs and ^{90}Sr from fallout and Navy activities are not necessarily only on the surface and may be present in both surface and subsurface soil.
	• Potential for isolated radiological commodities randomly distributed around the site.
	• Trenches where scan data exceeded the IL and biased soil samples were not collected.

Notes: ^{241}Am = americium-241
^{60}Co = cobalt-60
^{137}Cs = cesium-137
^{3}H = hydrogen-3
^{239}Pu = plutonium-239
^{226}Ra = radium-226
^{90}Sr = strontium-90
^{232}Th = thorium-232
^{235}U = uranium-235

BRAC = Base Realignment and Closure
LLRW = low-level radioactive waste
NORM = naturally occurring radioactive material
NRDL = Navy Radiological Defense Laboratory
IL = investigation level
pCi/g = picocuries per gram

Table 3-1. Phase 1 Soil Trench Units, Parcel E

Former Trench Unit Name	Excavation of Original Trench Unit		Sidewalls + Floor		Totals		
	Estimated Volume of Original Excavation (cubic yards)[a]	Number of Excavation Soil Units[b]	Estimated Volume of 6-Inch Over-Excavation of Sidewalls + Floor (cubic yards)	Number of Sidewall Floor Units[b]	Volume (cubic yards)	Number of Units	Number of Systematic Samples[c]
TU-152	494	2	135	1	629	3	42
TU-158	612	3	161	1	773	4	56
TU-159	364	2	114	1	478	3	42
TU-162	442	2	124	1	566	3	42
TU-163	636	3	166	1	802	4	56
TU-214	775	3	191	1	966	4	56
TU-217	1,080	4	193	1	1,273	5	70
TU-222	450	2	176	1	626	3	42
TU-223	795	3	184	1	979	4	56
TU-235	411	2	154	1	565	3	42
TU-245	942	4	133	1	1,075	5	70
TU-246	1,152	4	139	1	1,291	5	70
TU-300	1,056	4	187	1	1,243	5	70
TU-301	1,220	5	193	1	1,413	6	84
TU-307	1,080	4	190	1	1,270	5	70
TU-340	906	4	179	1	1,085	5	70
TU-341	1,604	6	162	1	1,766	7	98
TU-342	1,216	5	177	1	1,393	6	84
TU-345	1,597	6	187	1	1,784	7	98
TU-346	1,157	4	191	1	1,348	5	70

Total Excavation Volume (cubic yards): **21,325**

Total Number of Units: **92**

Total Number of Systematic Samples: **1,288**

Notes: [a] The estimated volume of the original excavation was derived using the Estimated Backfill Quantity information provided in Table 1 of the Performance Work Statement, Radiological Confirmation Sampling and Survey at Parcel E, Former Hunters Point Naval Shipyard, San Francisco, California.

[b] The number of Excavation Soil Units and Sidewall Floor Units are calculated from dividing the estimated volume of the excavation by 298 yd^3, which is based on a volume of 1,000 m^2 x 9 inches = 298 yd^3 (~327 tons of soil).

[c] Assumes 14 systematic samples in each survey unit.

Table 3-2. Phase 2 Soil Trench Units, Parcel E

Trench Unit	Surface Area [ft^2][a]	Number of Systematic Borings in Original TU Material	Number of Samples in Original TU Material	Number of Borings from Sidewalls and Bottom[b]	Number of Samples from Sidewalls and Bottom
TU-154	323	14	42	2	6
TU-155	291	14	42	2	6
TU-156	5,134	14	42	12	36
TU-157	9,020	14	42	24	72
TU-160	8,267	14	42	18	54
TU-161	7,319	14	42	22	66
TU-165	710	14	42	2	6
TU-201	3,132	14	42	8	24
TU-215	10,290	14	42	28	84
TU-216	10,290	14	42	16	48
TU-218	9,139	14	42	18	54
TU-224	9,827	14	42	24	72
TU-225	10,409	14	42	2	6
TU-228	10,247	14	42	22	66
TU-229	10,183	14	42	10	30
TU-230	9,623	14	42	12	36
TU-240	1,238	14	42	4	12
TU-241	6,114	14	42	18	54
TU-248	9,914	14	42	18	54
TU-249	10,183	14	42	22	66
TU-305	10,430	14	42	36	108
TU-306	9,838	14	42	26	78
TU-308	10,312	14	42	20	60
TU-309	10,226	14	42	22	66
TU-310	8,686	14	42	18	54
TU-311	3,950	14	42	6	18
TU-343	9,558	14	42	18	54
TU-344	9,160	14	42	16	48
TU-347	10,247	14	42	20	60
TU-348	10,506	14	42	12	36
TU-349	10,064	14	42	10	30
TU-350	7,083	14	42	10	30
TU-351	6,243	14	42	10	30
TU-352	7,567	14	42	12	36
TU-353	4,585	14	42	10	30
TU-354	5,554	14	42	14	42
TU-355	4,133	14	42	12	36
		Sample Subtotals:	**1,554**		**1,668**

Total Number of Systematic Samples (Original TU Material + Sidewalls and Bottom) is 3,222

Notes [a]From Table 2 of the Performance Work Statement, Radiological Confirmation Sampling and Survey at Parcel E, Former Hunters Point Naval Shipyard, San Francisco, California.
[b]Assumes a boring every 50 linear feet of trench on each sidewall

Table 3-3. Former Building Sites Soil Survey Units

Building Site	Former Class 1 Survey Unit Name	Former Class 2 Survey Unit Name	Area [m^2]	Number of Systematic Samples [a]
Former Building Site 517	SU1 and SU2		2,249	28
Former Building Site 503	SU1 – SU24		32,669	336
Former Building Site 520	SU1 – SU5		3,246	70
Former Building Site 506	SU1 – SU5		3,640	70
Former Building Site 508	SU1		1,496	14
Former Building Site 510	SU1		1,914	14
Former Building Site 529	SU1		392	14
IR-04 Former Scrap Yard and Former Building 807 Site	SUs 1 – SU9	SU10	7,040	140
Former Building Site 704	SU1 and SU3	SU4	1,219	42
Former Building Site 704 Storage Yard	SU1, SU3, SU4, SU6	SU7	1,384	70
Former Building Site 707 Triangle	SU1 – SU23		19,967	322
Former Building Site 500 Series	SU1 – SU27		41,473	378
Former Building Site Shack 79 and 80	SU1, SU2, and SU3		2,591	42
			Total Number of Systematic Samples	**1,540**

Notes: [a]Assumes 14 systematic samples in each survey unit.

Table 3-4. Soil Radionuclides of Concern

Soil Area	Radionuclide of Concern
Former Sanitary Sewer and Storm Drain Lines	^{137}Cs, ^{226}Ra, ^{90}Sr
Former Building Sites	^{137}Cs, ^{241}Am, ^{226}Ra, ^{90}Sr, ^{60}Co, ^{239}Pu, ^{235}U, ^{3}H
Building Surveys	^{137}Cs, ^{226}Ra, ^{90}Sr, ^{239}Pu

Notes: ^{90}Sr = strontium-90 (for former sanitary sewer and storm drain lines, former building sites, and interior surfaces of Buildings 521 and 810)
^{3}H = hydrogen-3 (only for former Building 506 site)
^{239}Pu = plutonium-239 (only for interior surfaces of Building 521 and the sites of former Buildings 506, 510, 704, 704 Storage Yard, 707 Triangle, and the 500 Series)
^{60}Co = cobalt-60 (only for former Building 517 site)
^{226}Ra = radium-226 (for former Building sites)
^{241}Am = americium-241 (only for former Buildings 506 and the 500 Series)
^{235}U = uranium-235 (only for former Building 707 Triangle site)

Table 3-5. Soil Remediation Goals from Parcel E Record of Decision

Radionuclide	Background Threshold Values (pCi/g)	*Net* Residential Soil Remediation Goal (pCi/g)	*Gross* Residential Soil Goal (pCi/g)
^{137}Cs	0.141	0.113	0.254
^{239}Pu	0.515	2.59	3.105
^{226}Ra	0.861	1.861	1.861
^{60}Co	-	0.252	0.252
^{90}Sr	0.150	0.331	0.481
^{241}Am	-	1.36	1.360
^{235}U	0.145	0.195	0.340

Notes: pCi/g = picocuries per gram
^{241}Am = americium-241
^{60}Co = cobalt-60
^{137}Cs = cesium-137
^{239}Pu = plutonium-239
^{226}Ra = radium-226
^{90}Sr = strontium-90
^{235}U = uranium-235

Table 3-6. Gamma Survey Instruments

Meter Manufacturer and Model	Detector Manufacturer and Model	Detector Type	Use
Perma-Fix Eagle iScan^{SM} System, Towed	Bicron 3x5x16/3SSL-X	3 inches x 5 inches x 16 inches (4-liter) NaI(Tl) detector	Ex situ RSY and soil area gamma scan surveys
Perma-Fix Eagle iScan^{SM} System, Handheld	Alpha Spectra 3x3	3 inches x 3 inches NaI(Tl) detector	Soil area gamma scans, sample screening, soil core surveys Building 414 SUs 1-13 floor scans

Notes: Equivalent alternative instrumentation may be used following approval by the PRSO and Field Team Lead.
NaI(Tl) = sodium iodide activated with thallium
PRSO = Project Radiation Safety Officer
RSY = Radiological Screening Yard

Table 3-7. A-Priori Scan Minimum Detectable Concentration (MDCs)

NaI Detector	Remediation Goal (RG)	Scan MDC
Eagle iScan, 3x3	^{226}Ra, 1.0 pCi/g	0.93 pCi/g
	^{137}Cs, 0.113 pCi/g	2.30 pCi/g
Eagle iScan 3x5x16	^{226}Ra, 1.0 pCi/g	0.5 pCi/g
	^{137}Cs, 0.113 pCi/g	0.5 pCi/g

Notes: NaI = sodium iodide
pCi/g = picocuries per gram
TBD = to be determined
^{137}Cs = cesium-137
^{226}Ra = radium-226

Table 3-8. Former Building Sites / Areas Radionuclides of Concern (ROCs)

Former Building Site	ROCs
517	^{137}Cs, ^{90}Sr, ^{60}Co, and ^{226}Ra
503	^{137}Cs, ^{90}Sr, and ^{226}Ra
520	^{137}Cs, ^{90}Sr, and ^{226}Ra
506	^{137}Cs, ^{90}Sr, ^{239}Pu, ^{241}Am, ^{226}Ra, and ^{3}H
508	^{137}Cs, ^{90}Sr, and ^{226}Ra
510	^{137}Cs, ^{90}Sr, ^{239}Pu, and ^{226}Ra
529	^{137}Cs, ^{90}Sr, ^{3}H, and ^{226}Ra
IR-04 Former Scrap Yard and 807	^{137}Cs, ^{90}Sr, and ^{226}Ra
704	^{137}Cs, ^{90}Sr, ^{239}Pu, and ^{226}Ra
704 Storage Yard	^{137}Cs, ^{90}Sr, ^{239}Pu, and ^{226}Ra
707 Triangle	^{137}Cs, ^{90}Sr, ^{239}Pu, ^{235}U, and ^{226}Ra
500 Series	^{137}Cs, ^{90}Sr, ^{239}Pu, ^{241}Am, and ^{226}Ra
Shack 79 and 80	^{137}Cs, ^{90}Sr, and ^{226}Ra

Notes: ^{241}Am = americium-241
^{60}Co = cobalt-60
^{137}Cs = cesium-137
^{3}H = hydrogen-3
^{239}Pu = plutonium-239
^{226}Ra = radium-226
^{90}Sr = strontium-90
^{235}U = uranium-235

Table 4-1. Building Radionuclides of Concern (ROCs)

Building	ROCs
Building 406	^{137}Cs and ^{226}Ra
Building 414	^{226}Ra
Building 521	^{137}Cs, ^{90}Sr, ^{239}Pu, and ^{226}Ra
Building 810	^{137}Cs, ^{90}Sr, and ^{226}Ra

Notes: ^{137}Cs = cesium-137
^{239}Pu = plutonium-239
^{226}Ra = radium-226
^{90}Sr = strontium-90

Table 4-2. Building Remediation Goals

Radionuclides of Concern	Particle Emissions	RGs for Structures, Equipment, or Waste, Total Radioactivity (dpm/100 cm^2)	RGs for Structures, Equipment, or Waste, Removable Radioactivity (dpm/100 cm^2)
^{137}Cs	β	5,000	1,000
^{239}Pu	α	100	20
^{226}Ra	α	100	20
^{90}Sr	β	1,000	200

Notes: dpm/100 cm^2 = disintegrations per minute per 100 square centimeters
RG = remediation goal
^{137}Cs = cesium-137
^{239}Pu = plutonium-239
^{226}Ra = radium-226
^{90}Sr = strontium-90
Total Radioactivity = fixed and removable
Removable Radioactivity RG assumed to be 20% of the total radioactivity RG

Table 4-3. Building-specific Remediation Goals

Building	RG_α (dpm/100 cm^2)		RG_β (dpm/100 cm^2)	
	Total	Removable	Total	Removable
Building 406	100 (^{226}Ra)	20 (^{226}Ra)	5,000 (^{137}Cs)	1,000 (^{137}Cs)
Building 414	100 (^{226}Ra)	20 (^{226}Ra)	N/A	N/A
Building 521	100 (^{239}Pu, ^{226}Ra)	20 (^{239}Pu, ^{226}Ra)	1,000 (^{90}Sr)	200 (^{90}Sr)
Building 810	100 (^{226}Ra)	20 (^{226}Ra)	1,000 (^{90}Sr)	200 (^{90}Sr)

Notes: dpm/100 cm^2 = disintegrations per minute per 100 square centimeters
RG = remediation goal
^{137}Cs = cesium-137
^{239}Pu = plutonium-239
^{226}Ra = radium-226
^{90}Sr = strontium-90

Table 4-4. Building Summary Table

Building	Former Uses	ROCs	Class 1 Survey Units	Class 2 Survey Units	Class 3 Survey Units	Corresponding Figure
406	Forty-two (42) Class 1 SUs (SU-1 to SU-42) consisting of concrete flooring and concrete (perimeter and SU-6 interior) lower walls (**Figure 4-2**). One Class 2 SU (SU-43), which includes all the concrete perimeter upper walls and the ceiling.	^{137}Cs, ^{226}Ra	SU-1 through SU-42	SU-43		4-1; 4-2
414	Nineteen (19) Class 1 SUs on the first floor (SU-1 to SU-19) consisting of concrete flooring, concrete support columns, concrete perimeter lower walls, some soil/gravel mixture in some areas (**Figure 4-3**). Survey Units 1 through 13 are covered in a soil/gravel mixture due to previous building work, the survey methods in these units will consist of fixed static (direct) and scan measurements for gamma radiation. Subsequently, soil samples will be collected to evaluate the presence of the ROCs. One Class 2 SU (SU-20) formed by the first floor concrete ceiling and concrete perimeter upper walls.	^{226}Ra	SU-1 through SU-19	SU-20		4-1; 4-3
521	Six (6) Class 1 SUs (SU-1 to SU-3 and SU-5 to SU-7) consisting of either concrete flooring and concrete lower walls (**Figure 4-4**) or concrete trench floors and walls. One Class 2 SU (SU-4) for the upper walls (2 to 4 meters above the respective floor surfaces) and one Class 3 SU (SU-8) for the roof area.	^{137}Cs, ^{90}Sr, ^{239}Pu, ^{226}Ra	SU-1 through SU-3 and SU-5 through SU-7	SU-4	SU-8	4-1; 4-4
810	Twenty-eight (28) Class 1 SUs (SU-1 to SU-28) covering the floors and walls less than or equal to 2 meters above the respective floor areas (less than 100 m^2 of floor area each). One Class 2 SU (SU-29) for the area 2 to 4 meters above the respective floor surfaces.	^{137}Cs, ^{90}Sr, ^{226}Ra	SU-1 through SU-28	SU-29		4-1; 4-5

Notes: m^2 = square meters
ROC = radionuclide of concern
SU = survey snit

Table 4-5. Typical Survey Instrument Efficiencies and Background Count Rates from Manufacturers

Parameter	ERG Model 102F	Ludlum Model 43-37	Ludlum Model 43-68	Ludlum Model 43-93	Ludlum Model 3030
Type of Measurement	**Scanning**	**Scanning**	**Scanning/Static**	**Scanning/Static**	**Smear Counting**
Detector active area, A (cm^2)	100	584	126	100	20.3
Width in direction of scan, d (cm)	10	13.3	8.8	6.9	NA
Alpha total efficiency (4-π) for ^{239}Pu	0.21	0.175	0.175	0.20	0.37
Alpha total efficiency (4-π) for ^{226}Ra	0.13	NA	NA	NA	0.32
Beta total efficiency (4-π) for ^{90}Sr/^{90}Y	0.13	0.20	0.20	0.20	0.26
Beta total efficiency (4-π) for ^{137}Cs		NA	NA	NA	0.29
Alpha background (cpm)	1	< 10	≤ 3	≤ 3	≤ 3
Beta background (cpm)	126	800 - 1300	350	≤ 300	≤ 50

Notes: ^{137}Cs = cesium-137
^{239}Pu = plutonium-239
^{226}Ra = radium-226
^{90}Sr = strontium-90
^{90}Y = yttrium-90
< = less than
≤ = less than or equal to
cm = centimeter
cm^2 = square centimeter
cpm = counts per minute
ERG = Environmental Restoration Group
NA = not applicable

Table 4-6. Detector Efficiencies for Each ROC and Alpha-emitting or Beta-emitting Progeny

				4-π Efficiencies (Estimated)					4-π Weighted Efficiencies (Estimated)				
Parent ROC and Alpha- or Beta-emitting Progenies	**Particle Emission**	**Decay Fraction**	**Equilibrium Fraction**	**ERG Model 102F**	**Ludlum Model 43-37**	**Ludlum Model 43-68**	**Ludlum Model 43-93**	**Ludlum Model 3030**	**ERG Model 102F**	**Ludlum Model 43-37**	**Ludlum Model 43-68**	**Ludlum Model 43-93**	**Ludlum Model 3030**
^{137}Cs	Beta	1.00	1.00	0.103	0.200	0.200	0.200	0.290	0.103	0.200	0.200	0.200	0.290
^{239}Pu	Alpha	1.00	1.00	0.210	0.175	0.175	0.200	0.370	0.210	0.175	0.175	0.200	0.370
^{226}Ra	Alpha	1.00	1.00	0.130	0.175	0.175	0.200	0.320	0.130	0.175	0.175	0.200	0.320
^{222}Rn	Alpha	1.00	1.00	0.130	0.175	0.175	0.200	0.370	0.130	0.175	0.175	0.200	0.370
^{218}Po	Alpha	1.00	0.40	0.130	0.175	0.175	0.200	0.370	0.052	0.070	0.070	0.080	0.148
^{214}Pb	Beta	1.00	0.40	0.103	0.200	0.200	0.200	0.260	0.041	0.080	0.080	0.080	0.104
^{214}Bi	Beta	1.00	0.40	0.103	0.200	0.200	0.200	0.260	0.041	0.080	0.080	0.080	0.104
^{214}Po	Alpha	1.00	0.40	0.130	0.175	0.175	0.200	0.370	0.052	0.070	0.070	0.080	0.148
^{210}Pb	Beta	1.00	0.40	0.103	0	0	0	0	0.041	0	0	0	0
^{210}Bi	Beta	1.00	0.40	0.103	0.200	0.200	0.200	0.260	0.041	0.080	0.080	0.080	0.104
^{210}Po	Alpha	1.00	0.40	0.130	0.200	0.175	0.200	0.370	0.052	0.080	0.070	0.080	0.148
		Total ^{226}Ra alphas	***3.20***						***0.41***	***0.570***	***0.560***	***0.640***	***1.134***
		Total ^{226}Ra betas	***1.60***						***0.165***	***0.240***	***0.240***	***0.240***	***0.312***
^{90}Sr	Beta	1.00	1.00	0.130	0.200	0.200	0.200	0.260	0.130	0.200	0.200	0.200	0.260
^{90}Y	Beta	1.00	1.00	0.130	0.200	0.200	0.200	0.260	0.130	0.200	0.200	0.200	0.260
		Total ^{90}Sr betas	***2.00***						***0.260***	***0.400***	***0.400***	***0.400***	***0.520***

Notes: Total alphas or betas = sum of (decay fraction x equilibrium fraction)

^{208}Tl = thallium-208
^{210}Bi = bismuth-210
^{210}Pb = lead-210
^{214}Pb = lead-214
^{214}Po = polonium-214
^{218}Po = polonium-218
^{210}Po = polonium-210
^{212}Bi = bismuth-212

Table 4-7. Preliminary Instrument Scan Investigation Levels

ROC	ERG 102F (cpm)		Ludlum 43-37 (cpm)		Ludlum 43-68 (cpm)	
	Alpha	Beta	Alpha	Beta	Alpha	Beta
^{137}Cs	NA	641	NA	6,890	NA	1,610
^{239}Pu	22	NA	112	NA	25	NA
^{226}Ra	45	NA	359	NA	80	NA
^{90}Sr	NA	256	NA	2,218	NA	602

Notes: cpm = counts per minutes
NA = not applicable
ROC = radionuclide of concern
^{137}Cs = cesium-137
^{239}Pu = plutonium-239
^{226}Ra = radium-226
^{90}Sr = strontium-90

Table 4-8. Beta Scan Minimum Detectable Concentrations (dpm/100 cm^2) at 5 cm/s

ROC	ERG 102F	Ludlum Model 43-37
^{137}Cs	1,952	610
^{90}Sr	976	305

Notes: cm/s = centimeters per second
dpm/100 cm^2 = disintegrations per minute per 100 square centimeters
ERG = Environmental Restoration Group
ROC = radionuclide of concern
^{137}Cs = cesium-137
^{90}Sr = strontium-90

Table 4-9. Instrument Static Minimum Detectable Concentrations

	Ludlum Model 43-68 (dpm/100 cm^2)		Ludlum Model 43-93 (dpm/100 cm^2)		Ludlum Model 3030 (dpm/100 cm^2)	
ROC	Alpha	Beta	Alpha	Beta	Alpha	Beta
^{137}Cs	NA	357	NA	323	NA	85
^{239}Pu	50	NA	48	NA	20	NA
^{226}Ra	16	NA	15	NA	76	NA
^{90}Sr	NA	179	NA	323	NA	48

Notes: dpm/100 cm^2 = disintegrations per minute per 100 square centimeters
NA = not applicable
ROC = radionuclide of concern
SU background static measurement count times = 2 minutes
^{137}Cs = cesium-137
^{239}Pu = plutonium-239
^{226}Ra = radium-226
^{90}Sr = strontium-90

Table 7-1. Waste Management

Waste Stream	Source/Process	Staged in	Staged at	Final Disposition
Radiological Wastes (LLRW)				
Soil or sediment	Soil sampling/building cleaning activities	In accordance with 40 CFR 173, Subpart I	Navy approved location	Off-site disposal
Concrete and asphalt	Excavation/sampling	In accordance with 40 CFR 173, Subpart I	Navy approved location	Off-site disposal
Potential radiological commodities (e.g., deck markers)	Excavation/sampling	In accordance with 40 CFR 173, Subpart I	Navy approved location	Off-site disposal
Debris including PPE, plastic sheeting, disposable sampling equipment	Investigation activities involving disposable equipment	Include with soil/concrete	Navy approved location	Off-site disposal
Water from decontamination or dewatering	Excavation/sampling/equipment decontamination/building cleaning activities	In accordance with 40 CFR 173, Subpart I	Navy approved location	Off-site disposal
Nonradiological Wastes (Non-LLRW)				
Soil, sediment, concrete, or asphalt	Soil sampling/building cleaning activities	DOT specification drums or containers, IBC, or roll-off type bins	Navy approved location	Off-site disposal
Debris including PPE, plastic sheeting, disposable sampling equipment	Investigation activities involving disposable equipment	Include with soil	Navy approved location	Off-site disposal
Water from decontamination or dewatering	Excavation/sampling/equipment decontamination/building cleaning activities	DOT specification drums or containers	Navy approved location	Off-site disposal
Miscellaneous trash that has not contacted contaminated media	Investigation activities	Black non-translucent trash bags	Removed daily	Dumpsters at the Base

Notes: CFR = Code of Federal Regulations
DOT = United States Department of Transportation
LLRW = low-level radiological waste

Table 8-1. Derived Air Concentrations (DACs)

Radionuclide	DAC (µCi/mL)
^{226}Ra	3.0×10^{-10}
^{239}Pu	3.0×10^{-12}
^{235}U	6.0×10^{-10}
^{90}Sr	8.0×10^{-9}
^{137}Cs	6.0×10^{-8}

Notes: The most protective DACs for alpha and beta-emitting nuclides will be used as determined by the ROCs in that work area.

µCi/mL = microcuries per milliliter

^{137}Cs = cesium-137
^{239}Pu = plutonium-239
^{226}Ra = radium-226
^{90}Sr = strontium-90
^{235}U = uranium-235

Appendices